

## CHOICE EXPERIMENTS

The art of understanding choice behaviour,  
estimating willingness to pay, and  
predicting market shares

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Management & Organisations Department Seminar

The University of Western Australia

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THE UNIVERSITY OF  
SYDNEY



# Contents

- About me
- Introduction to choice experiments
- Application 1: Last mile parcel delivery choice
- Application 2: Route choice
- Application 3: Pandemic policy choice
- Final remarks

# About me



# About me

- **Professor at the University of Sydney**  
Institute of Transport and Logistics Studies  
Business School
- **Expertise**  
Discrete choice analysis and experimental design  
Transport planning and modelling
- **Associate Editor**  
Journal of Choice Modelling  
Transportation Research Part C



# Introduction to choice experiments

Bliemer, M.C.J., J.M. Rose (in press) Designing and conducted stated choice experiments.  
In: Hess, S., and A. Daly (eds) *Handbook of Choice Modelling*. Edward Elgar, second edition.

# Introduction to choice experiments

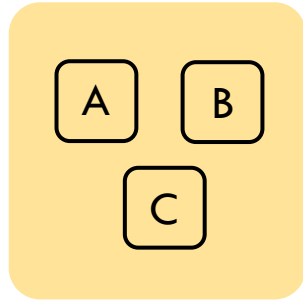
## Overview



Decision-maker



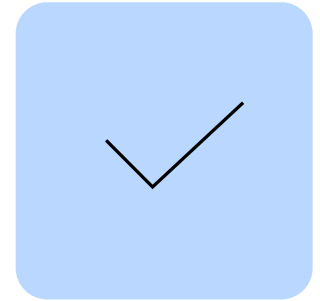
Scenario



Choice set



Decision rule

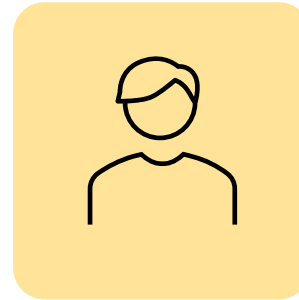


Choice

# Introduction to choice experiments

## Decision-maker

- Responsible for making a choice
  - Consumer
  - Traveller
  - Patient
  - Policy maker
  - Director of firm
  - ... etc



# Introduction to choice experiments

## Scenario

### – Choice context

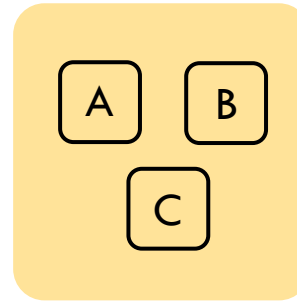
- Buying a laptop for at home
- Choosing a cancer treatment
- Flying overseas for holidays
- Selecting a new health provider
- Purchasing a new family car
- ... etc



# Introduction to choice experiments

## Choice set

- Relevant options to choose from
  - Apple, Samsung, Huawei
  - Surgery, chemotherapy, immunotherapy
  - Route A, Route B
  - Sedan, convertible, sports car, SUV
  - Current policy, new environmental policy
  - ... etc



# Introduction to choice experiments

## Decision rule

- Mathematical model that describes the behavioural process of choosing an option
  - Compensatory
  - Semi-compensatory
  - Elimination-by-aspects
  - Lexicographic
  - ...



# Introduction to choice experiments

## Daniel McFadden

- Nobel Prize winner in Economics in 2000
- Developed theories and methods to analyse choice behaviour
- Proposed **random utility maximisation**, a compensatory decision rule



# Introduction to choice experiments

## Random utility maximisation

- Utility has ordinal measurement scale
- Utility  $U_i$  for each option  $i$  consists of
  - Measurable component  $V_i$  containing characteristics of choice option  $i$
  - Random error term  $\varepsilon_i$  (Gumbel distribution)
- Decision-maker selects option  $i$  that maximises utility
- Probability  $P_i$  that option  $i$  is chosen can be computed analytically



# Introduction to choice experiments

## Computing choice probabilities

### – Logit model

$$U_i = V_i + \varepsilon_i$$

$$P_i = \frac{\exp(\lambda V_i)}{\sum_j \exp(\lambda V_j)}$$

- Additive error terms
- Assumes that decision makers evaluate absolute differences in utility

### – Weibit model

$$U_i = V_i \cdot \varepsilon_i$$

$$P_i = \frac{(-V_i)^{-\lambda}}{\sum_j (-V_j)^{-\lambda}}$$

- Multiplicative error terms
- Assumes that decision makers evaluate relative differences in utility

# Introduction to choice experiments

## Choice experiment

- Agent is given a series of **hypothetical choice tasks**
- Agent is asked to make **trade-offs** across attributes of alternative options
- Data can be used to **estimate utility functions** (logistic regression)

You are looking to buy a new laptop **for use at home**.  
Which of the following laptops would you prefer?

Laptop A	Laptop B	Laptop C
15" screen Intel Core i5 processor 16 GB RAM 256 GB HDD \$2100	13" screen Intel Core i7 processor 8 GB RAM 1 TB HDD \$1800	13" screen Intel Core i5 processor 8 GB RAM 512 GB HDD \$1500
<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

# Introduction to choice experiments

## Outcomes of choice experiment

- most important attributes
- willingness-to-pay for certain attributes
- demand forecasts
- predicted market shares

# Application 1

## Last mile parcel delivery choice

Merkert, R., M.C.J. Bliemer, M. Fayyaz (2022) Consumer preferences for innovative and traditional last-mile parcel delivery. *International Journal of Physical Distribution & Logistics Management*, Vol. 53(3), pp. 261-284.

# Application 1: Last mile parcel delivery choice

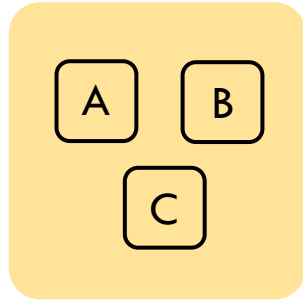
## Study overview



Consumer



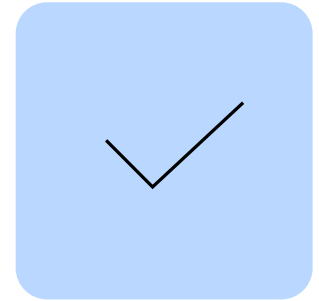
Parcel delivery



Postie,  
Drone,  
Parcel locker



Random  
utility  
maximisation



Choice

# Application 1: Last mile parcel delivery choice

## Main research questions

- Would consumers consider drones for parcel delivery?
- What attributes are most important?
- How much are consumers willing to pay for fast delivery?



# Application 1: Last mile parcel delivery choice

## Choice experiment | Scenario

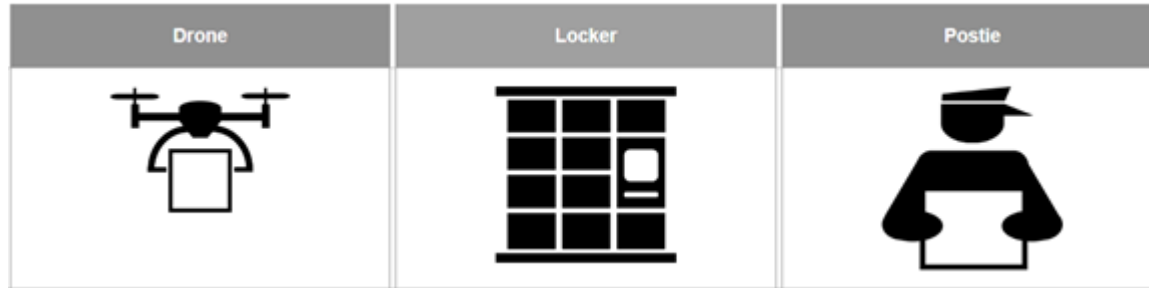
- “Consider buying [good] online or via phone from a domestic retailer with an estimated value of [value] Australian dollars”
- [good] and [value] correspond to most recent parcel delivered to respondent (reported by respondent in online survey)



# Application 1: Last mile parcel delivery choice

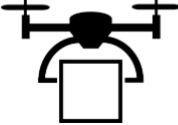


## Choice experiment | Choice set

### – Delivery modes



# Application 1: Last mile parcel delivery choice

## Choice experiment | Example choice task

	Drone	Locker	Postie
			
Speed	2 business days	3 business days	5 business days
Delivery method	Leave in a safe place	Secure in locker	Leave at front door
Time window	9am - 5pm (30 minutes)	24/7 (kept for two days)	6pm - 9pm (no choice)
Cost	\$2	\$6	\$8
Which would you choose?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

# Application 1: Last mile parcel delivery choice

## Choice experiment | Attribute: Delivery speed

### – Levels

- Express - within 2 hours (only drone) \*
- Express - same day \*
- Express - next business day \*
- 2 business days
- 3 business days
- 5 business days

\* Not available for respondents living in rural areas

# Application 1: Last mile parcel delivery choice

## Choice experiment | Attribute: Delivery method

### – Levels

- Leave at front door
- Leave in a safe place \*
- Signature required (only postie)
- Secure in locker

\* Not available when respondent indicates to have no safe place around their residence

# Application 1: Last mile parcel delivery choice

## Choice experiment | Attribute: Delivery time window

### – Levels

- Daytime (9am-5pm)
- Daytime (9am-5pm): select 2-hour window
- Daytime (9am-5pm): select 3-hour window
- Evening (6-9pm) (only postie)

# Application 1: Last mile parcel delivery choice

## Choice experiment | Attribute: Delivery cost

### – Levels for small parcel (<1kg)

- \$2, \$4 (only drone)
- \$6, \$8, \$10, \$12, \$14
- \$16, \$18 (only postie/locker)

### – Levels for large parcel (1-5kg)

- \$8, \$10 (only drone)
- \$12, \$14, \$16, \$18, \$20
- \$22, \$24 (only postie/locker)

# Application 1: Last mile parcel delivery choice

## Methodology

### – Experimental design

- D-efficient design
- 10 choice tasks per respondent, tailored to each respondent
- Dominant alternatives are excluded
- High degree of attribute level balance

### – Model estimation

- Random utility theory with additive error terms
- Error component panel mixed logit model
- Numerical and dummy coding
- Maximum likelihood estimators

# Application 1: Last mile parcel delivery choice

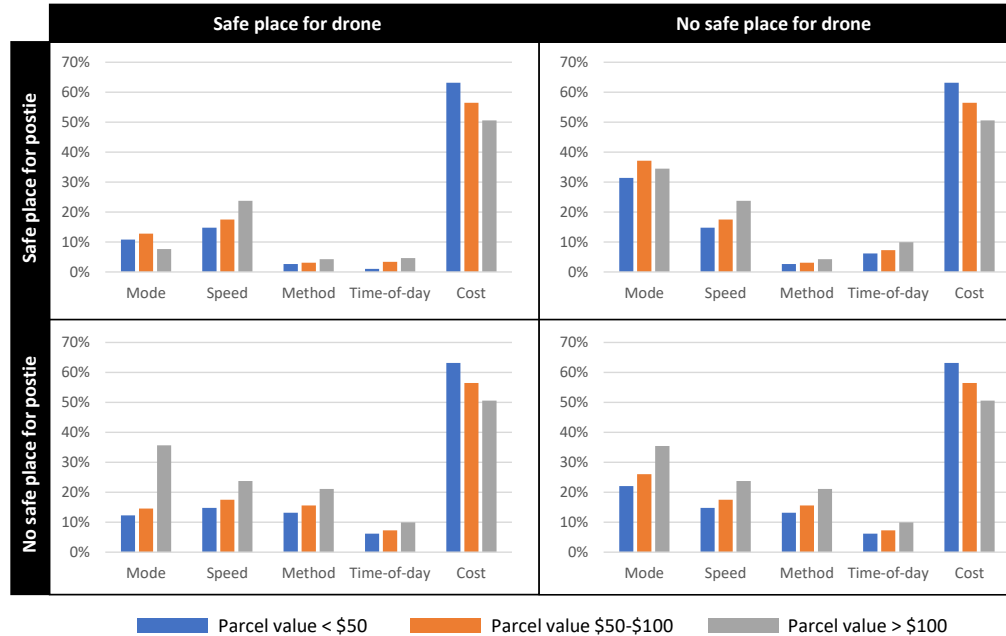
## Data collection

- Australia
- March/April 2020
- 1,003 respondents
- 10,030 choice observations



# Application 1: Last mile parcel delivery choice

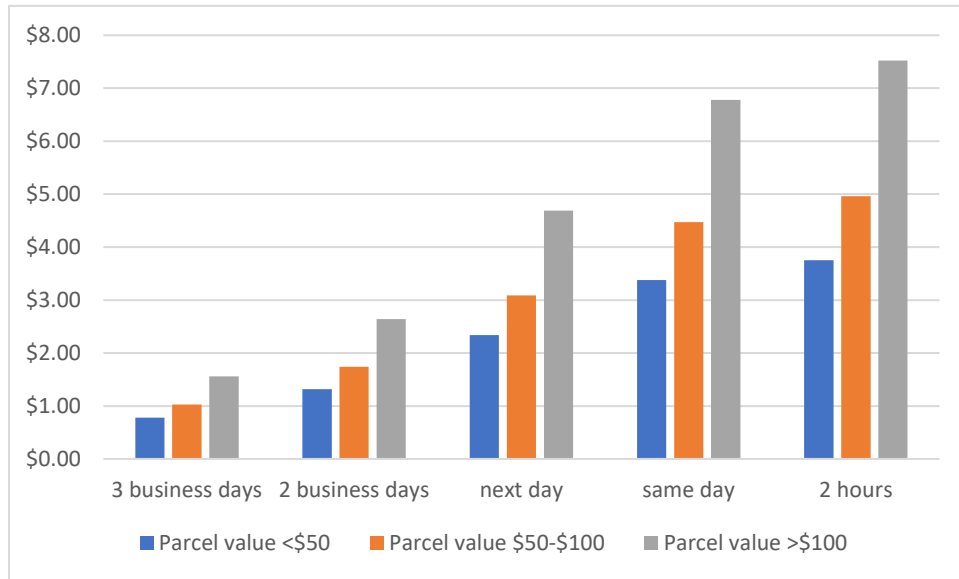
## Relative importance of attributes



# Application 1: Last mile parcel delivery choice

## Willingness-to-pay for fast delivery

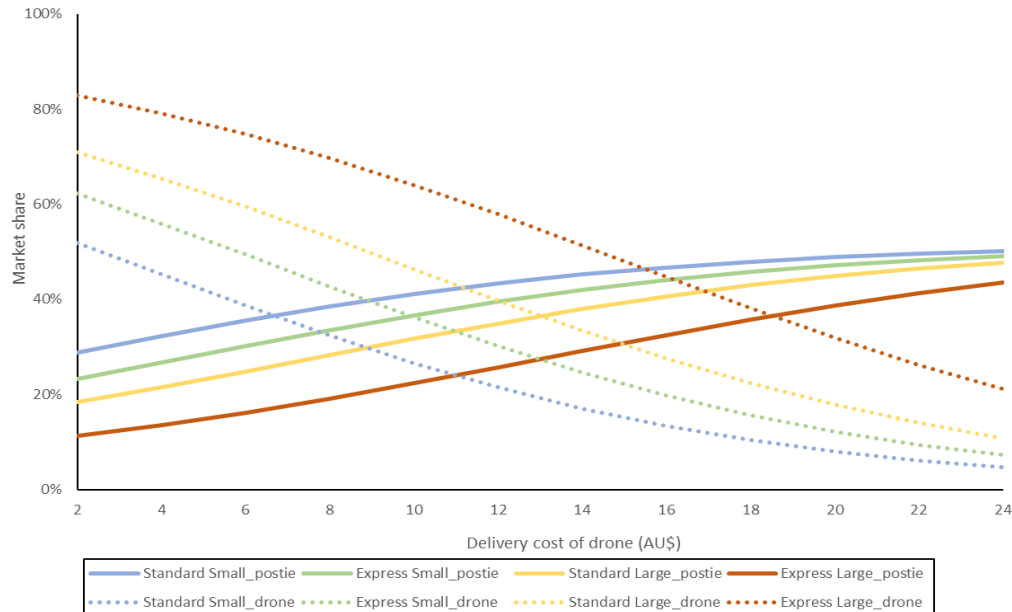
- Relative to '5 business days' delivery



# Application 1: Last mile parcel delivery choice

## Predicted market shares

- Application of logit model



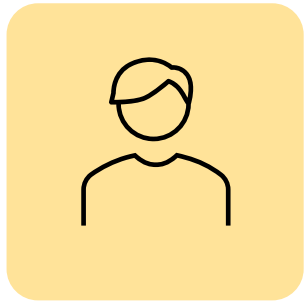
# Application 2

## Route choice

Fayyaz, M., M.C.J. Bliemer, M.J. Beck, S. Hess, J.W.C. van Lint (2021) Stated choices and simulated experiences: differences in the value of travel time and reliability. *Transportation Research Part C*, Vol. 128, 103145.

# Application 2: Route choice

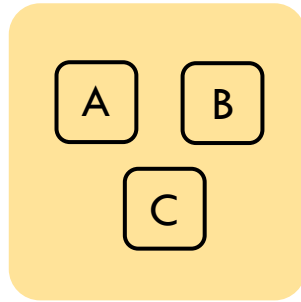
## Study overview



Driver



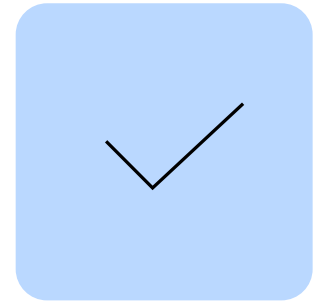
Commute  
route choice



Urban road,  
Tolled motorway



Random  
utility  
maximisation



Choice

# Application 2: Route choice

## Main research questions

- How much toll are people willing to pay for less travel time?
- How much are people willing to pay to reduce travel time unreliability?

# Application 2: Route choice

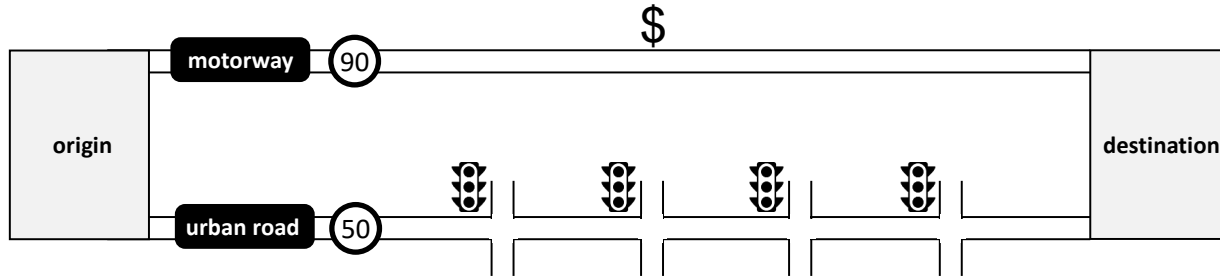
## Choice experiment | Scenario

- Consider travelling to work by car



# Application 2: Route choice

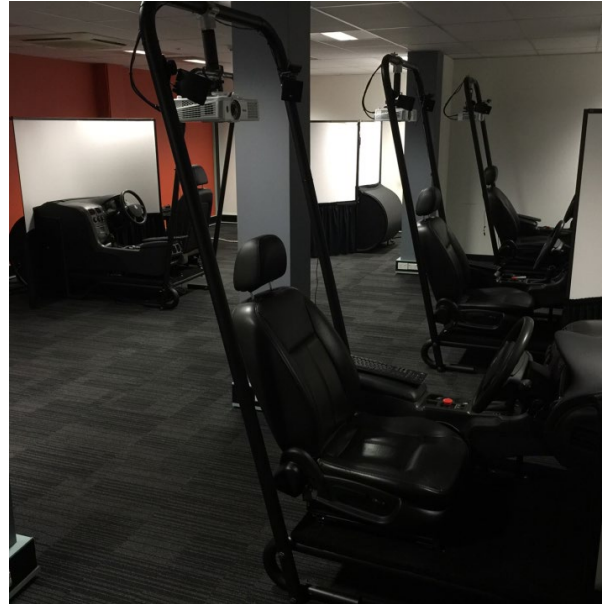
## Choice experiment | Choice set



# Application 2: Route choice

## Travel Choice Simulation Laboratory (TRACSLab)

- 5 medium fidelity driving simulators



# Application 2: Route choice

Travel Choice Simulation Laboratory (TRACSLab)



# Application 2: Route choice

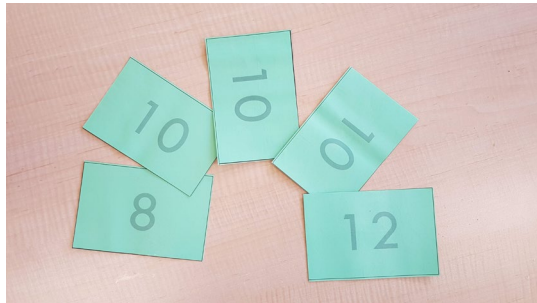
## Choice experiment | Example choice task

Motorway	Urban road										
Speed limit of <b>90 km/h</b> , <b>no traffic lights</b> .	Speed limit of <b>50 km/h</b> , <b>four traffic lights</b> .										
The travel time is <b>6 minutes</b> every day.  <table border="1"><tr><td>6</td><td>6</td><td>6</td><td>6</td><td>6</td></tr></table>	6	6	6	6	6	The travel time varies. You will experience one of the following <b>travel times (in minutes)</b> with equal probability:  <table border="1"><tr><td>8</td><td>10</td><td>10</td><td>10</td><td>12</td></tr></table>	8	10	10	10	12
6	6	6	6	6							
8	10	10	10	12							
Toll cost: <b>\$ 2.00</b>	Toll cost: <b>\$ 0.00</b>										

# Application 2: Route choice

## Choice experiment | Attribute: Travel time

- **Motorway**
  - Reliable
  - 6 minutes
- **Urban road**
  - Unreliable
  - Between 2 and 12 minutes



# Application 2: Route choice

## Choice experiment | Attribute: Toll

- Motorway
  - \$1, \$2, \$3
- Urban road
  - \$0



# Application 2: Route choice

## Methodology

### – Experimental design

- D-efficient design
- 5 choice tasks per respondent, selected from a list of 15 unique choice tasks
- Dominant alternatives are excluded
- High degree of attribute level balance

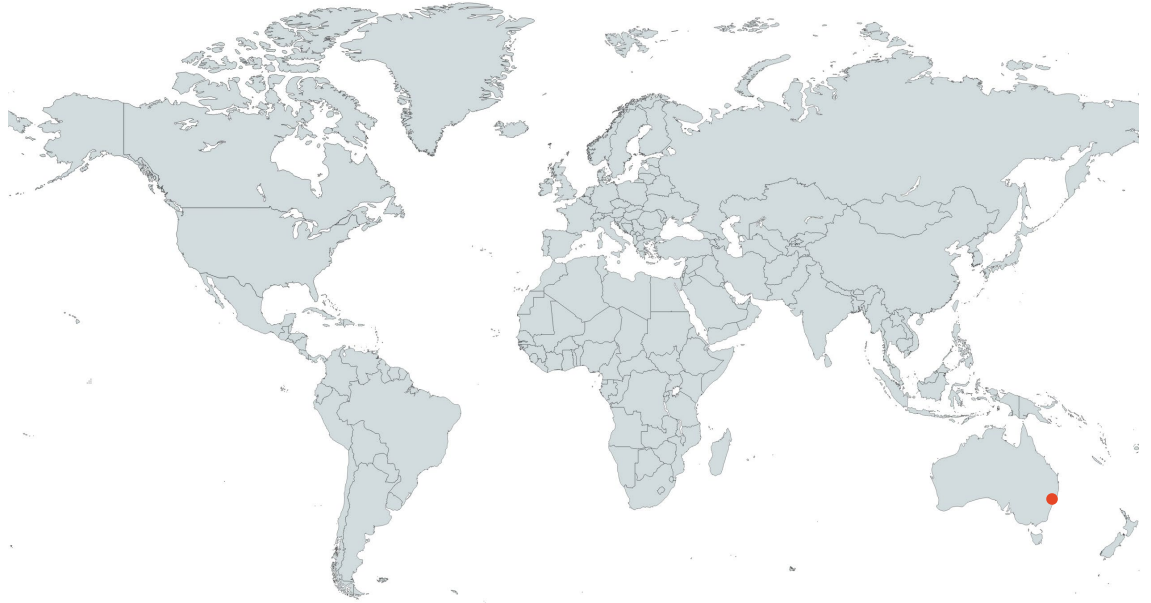
### – Model estimation

- Random utility theory with additive error terms
- Heteroscedastic panel latent class model
- Numerical and dummy coding
- Maximum likelihood estimators

# Application 2: Route choice

## Data collection (driving simulator laboratory)

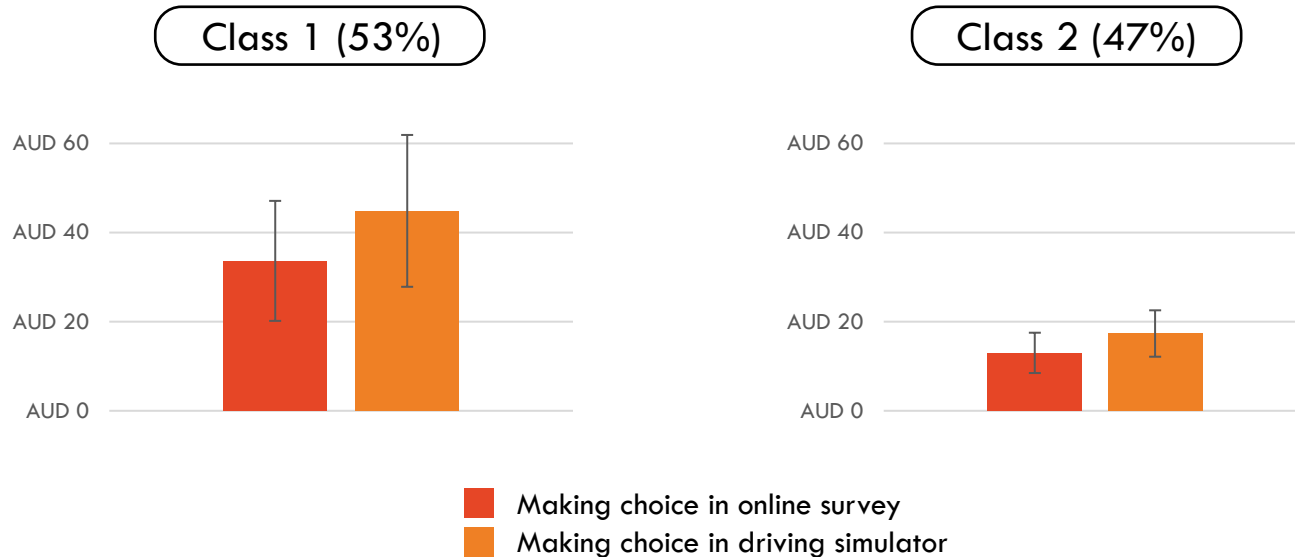
- Sydney
- Sept 2017 – Nov 2018
- 74 participants
- 370 choice observations



# Application 2: Route choice

## Value of travel time

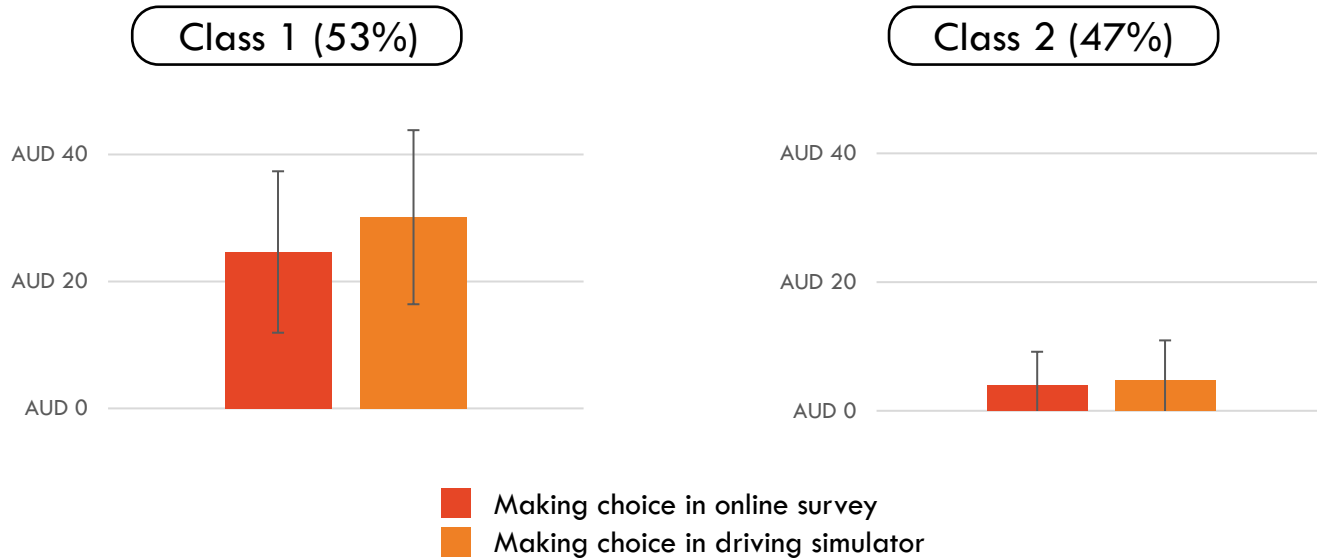
- Willingness-to-pay for 1 hour less travel time



# Application 2: Route choice

## Value of reliability

- Willingness-to-pay for 1 hour less standard deviation of travel time



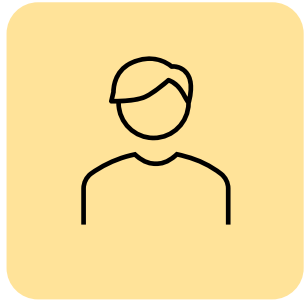
# Application 3

## Pandemic policy choice

Bliemer, M.C.J., M. Beck, C. Chorus (on-going) Not yet published.

# Application 3: Pandemic policy choice

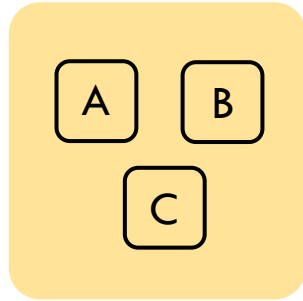
## Study overview



Individual



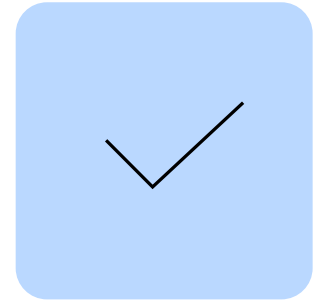
Future  
pandemic



Policy A,  
Policy B



Random  
utility  
maximisation



Choice

# Application 3: Pandemic policy choice

## Main research questions

- According to the people, which restrictions should the government put in place?
- What is more important: saving lives or protecting jobs?
- How many job losses are people willing to accept to save a life?



# Application 3: Pandemic policy choice

Moral dilemma – How to decide on restrictions?

*lockdown*



- Less deaths
- More job losses

*no restrictions*

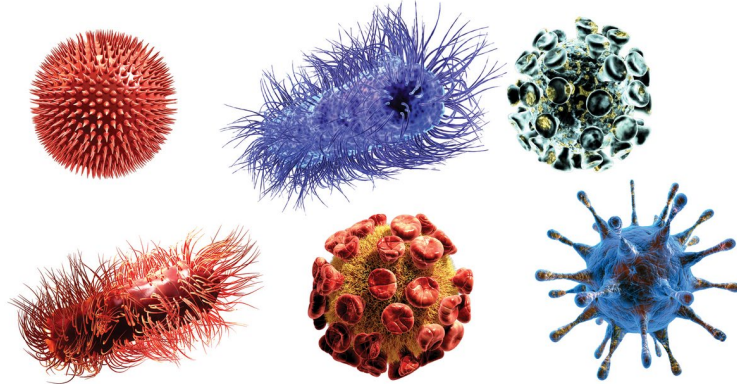


- More deaths
- Less job losses

# Application 3: Pandemic policy choice

## Choice experiment | Scenarios

- Consider a *future* pandemic, where
  - virus mainly affects younger people (e.g. Spanish flu), or
  - virus mainly affects older people (e.g. COVID-19)




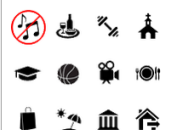
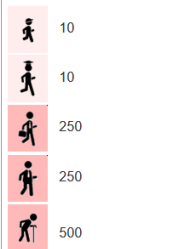
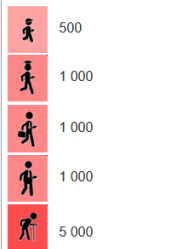

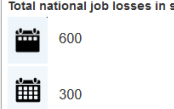
# Application 3: Pandemic policy choice

the 25 million people in

## Choice experiment | Example choice task

you of what each of them

### – Australian context

Policy A	Policy B
<b>Restrictions on activities (for 4 months):</b> 	<b>Restrictions on activities (for 4 months):</b> 
<b>Total national deaths in each age group:</b> 	<b>Total national deaths in each age group:</b> 
<b>Total national job losses in short plus long term:</b> 	<b>Total national job losses in short plus long term:</b> 
<b>Which would you choose?</b>	
<input type="radio"/>	<input type="radio"/>

# Application 3: Pandemic policy choice

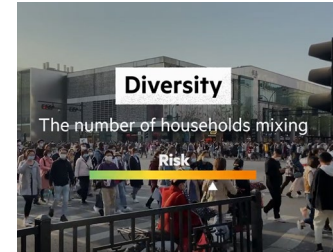
## Choice experiment | Attribute: Activity restrictions (1)

- Based on risk levels, depending on
  - Diversity (how many people are together)
  - Duration (how long are people together)
  - Distance (how close are people together)
- Based on expert advice
  - Sims et al. (2020)
  - Hassig (2020)
  - Miller et al. (2020)

COVID-19 RISK LEVELS		<a href="https://tinyurl.com/c19risk">tinyurl.com/c19risk</a>
9	• Bars • Big concerts	• Sports stadiums
8	• Gyms • Amusement parks	• Churches • Buffets
7	• Playing basketball • Public pools	• Schools
6	• Casinos • Restaurants – indoor • Playgrounds	• Hair salons, barbershops • Pontoon boat rides • Movie theaters
5	• Home dinner parties • Airplanes • Backyard barbecues	• Malls • Beaches • Bowling
4	• Dentist offices • Walking in busy downtown • Offices	• Doctor waiting rooms • Restaurants – outdoor
3	• Grocery stores • Camping • Hotels	• Golfing • Libraries, museums
2	• Walk, run, or bike with others	• Get car gasoline
1	• Restaurants – takeout	• Tennis

Dr. Matthew Sims, Dr. Dennis Cunningham, Dr. Mimi Enig, Dr. Nasir Hussain. Based on risk factors including indoor/outdoor, openness to others, exposure time, compliance likelihood, and personal risk.

Source: Sims et al. (2020)



Source: Business Insider

# Application 3: Pandemic policy choice

## Choice experiment | Attribute: Activity restrictions (2)

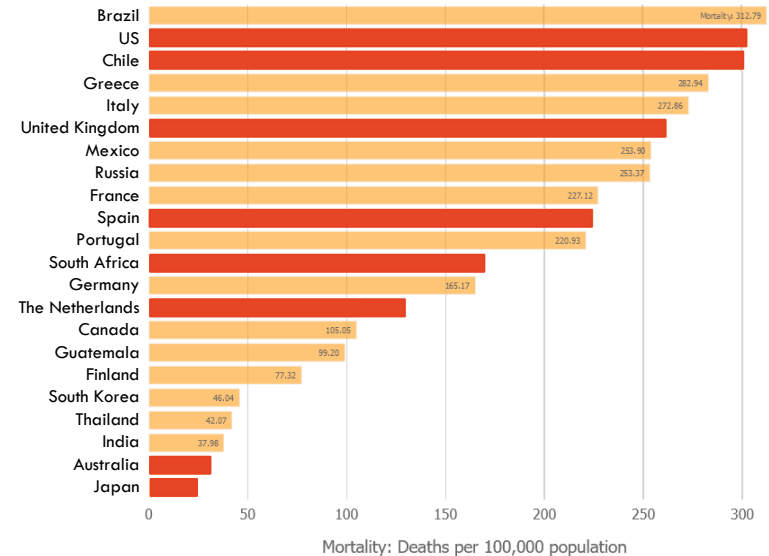
– 13 categorical levels



# Application 3: Pandemic policy choice

## Choice experiment | Attribute: Death rate (1)

- Levels based on reported COVID-19 mortality rates
  - 0.1 to 500 (per 100,000)
- 5 age groups:
  - Children
  - Adolescents
  - Young adults
  - Middle aged
  - Seniors



Source: John Hopkins University, 14 May 2022

# Application 3: Pandemic policy choice

## Choice experiment | Attribute: Death rate (2)

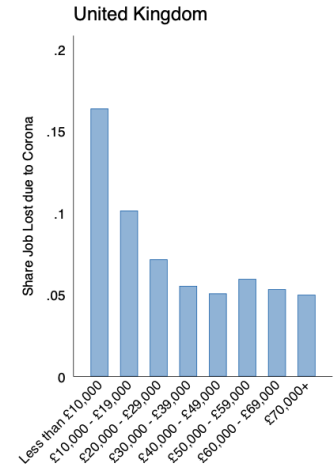
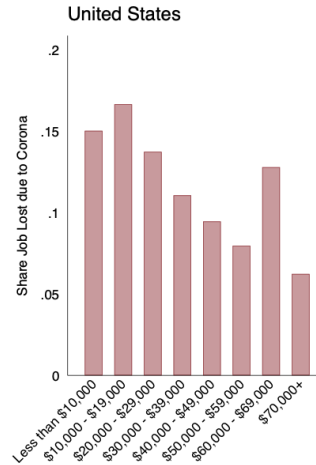
- 12 numerical levels (exponential) using colour-coded pictograms



# Application 3: Pandemic policy choice

## Choice experiment | Attribute: Unemployment rate (1)

- Levels based on reported COVID-19 job losses
  - 0.005% to 20% of working population
- 2 unemployment durations:
  - Short term job loss (4 months)
  - Long term job loss (12 months)



Source: VOX EU (2020)

# Application 3: Pandemic policy choice

## Choice experiment | Attribute: Unemployment rate (2)

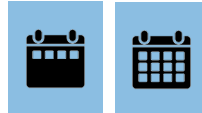
- 12 numerical levels (exponential) using colour-coded pictograms

Level 1      5 in 100,000



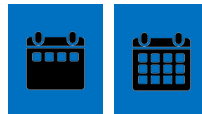
...      ...

Level 6      200 in 100,000



...      ...

Level 12      20,000 in 100,000



# Application 3: Pandemic policy choice

## Methodology

### – Experimental design

- D-efficient design
- 10 choice tasks per respondent, selected from a list of 1,000 unique choice tasks
- Dominant alternatives are excluded
- High degree of attribute level balance

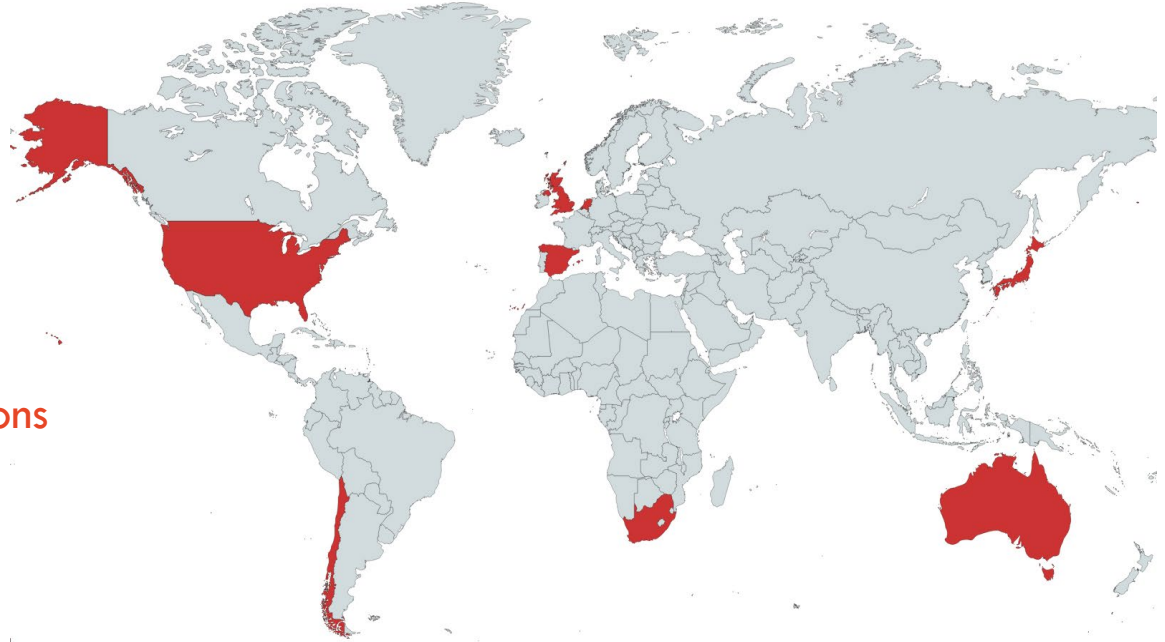
### – Model estimation

- Random utility theory with multiplicative error terms
- Heteroscedastic panel latent class model
- Orthogonal polynomial coding
- Maximum likelihood estimators

# Application 3: Pandemic policy choice

## Data collection (internet survey)

- 6 continents
- 4 languages
- 3 waves
  - dec 2020
  - dec 2021
  - dec 2022
- 5,000+ respondents
- 50,000+ choice observations



# Application 3: Pandemic policy choice

## Class-specific parameter estimates (robust t-ratios in brackets)

Attribute	Class A			Class B			Class C		
<b>Activity restrictions level</b>									
- Linear effect	-338.4	(-2.54)	**	-3169	(-4.36)	***	-30.38	(-3.51)	***
<b>Deaths</b>									
- Mean effect	-7882	(-6.84)	***	-306.0	(-5.08)	***	-0.2830	(-3.36)	***
- Linear age effect	2243	(4.44)	***	39.41	(2.85)	***	—	—	—
- Quadratic age effect	-603.4	(-1.99)	**	-107.9	(-3.86)	***	—	—	—
- Cubic age effect	—	—	—	—	—	—	—	—	—
- Quartic age effect	—	—	—	—	—	—	—	—	—
<b>Job losses</b>									
- Mean effect	-1	fixed		-1	fixed		-1	fixed	
- Linear duration effect	—	—	—	—	—	—	—	—	—

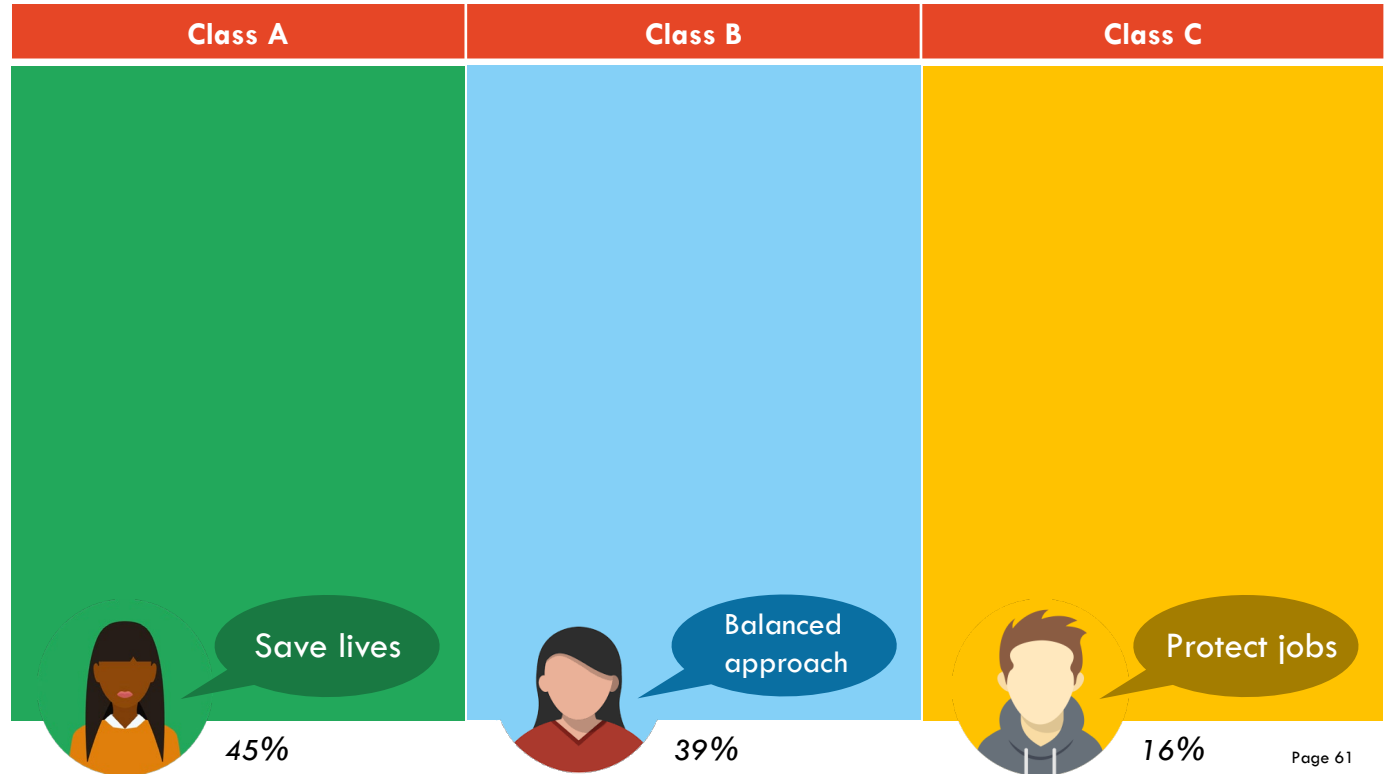
# Application 3: Pandemic policy choice

## Relative importance of attributes (partworths)

Attribute	Class A			Class B			Class C		
<b>Activity restrictions level</b>	1%			19%			0%		
- Linear effect	-338.4	(-2.54)	**	-3169	(-4.36)	***	-30.38	(-3.51)	***
<b>Deaths</b>	99%			71%			1%		
- Mean effect	-7882	(-6.84)	***	-306.0	(-5.08)	***	-0.2830	(-3.36)	***
- Linear age effect	2243	(4.44)	***	39.41	(2.85)	***	—	—	—
- Quadratic age effect	-603.4	(-1.99)	**	-107.9	(-3.86)	***	—	—	—
- Cubic age effect	—	—	—	—	—	—	—	—	—
- Quartic age effect	—	—	—	—	—	—	—	—	—
<b>Job losses</b>	0%			9%			99%		
- Mean effect	-1	fixed		-1	fixed		-1	fixed	
- Linear duration effect	—	—	—	—	—	—	—	—	—

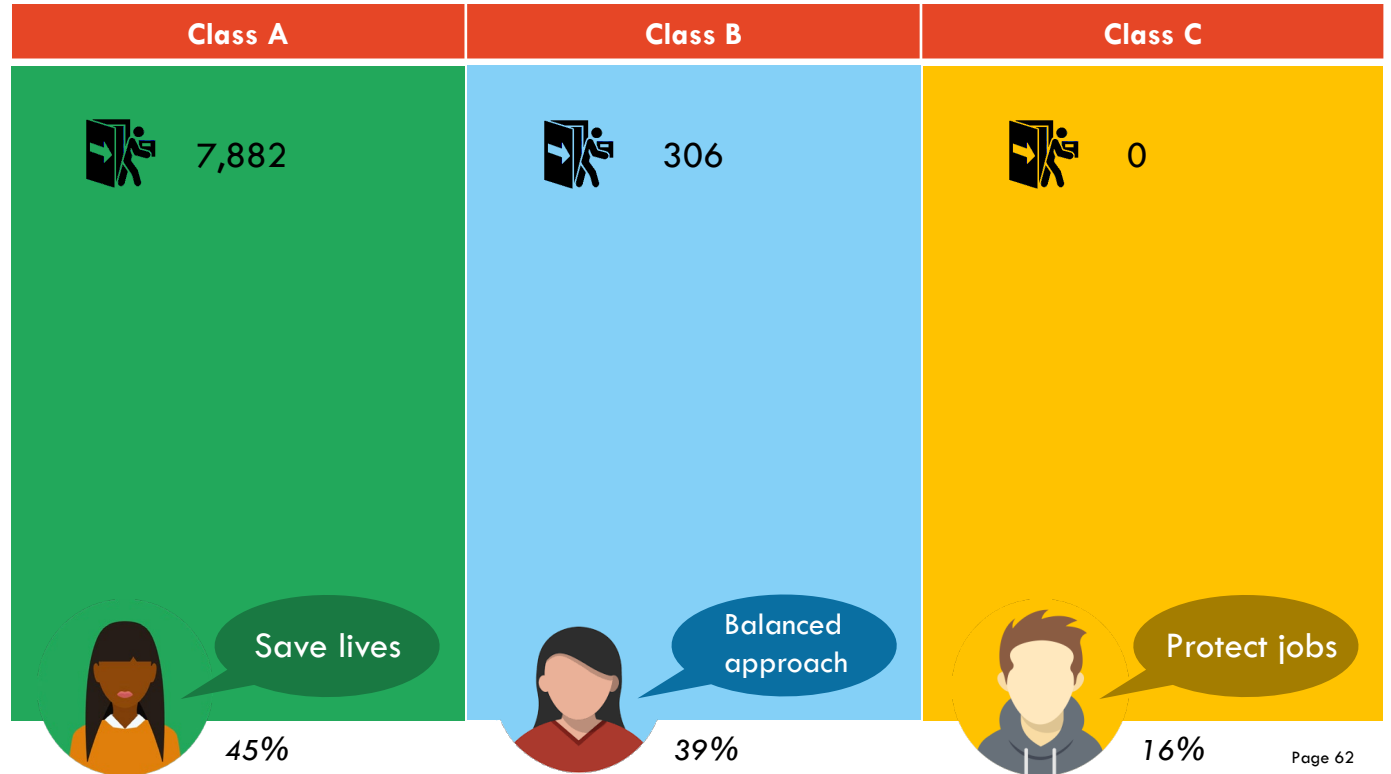
# Application 3: Pandemic policy choice

## Interpretation of classes



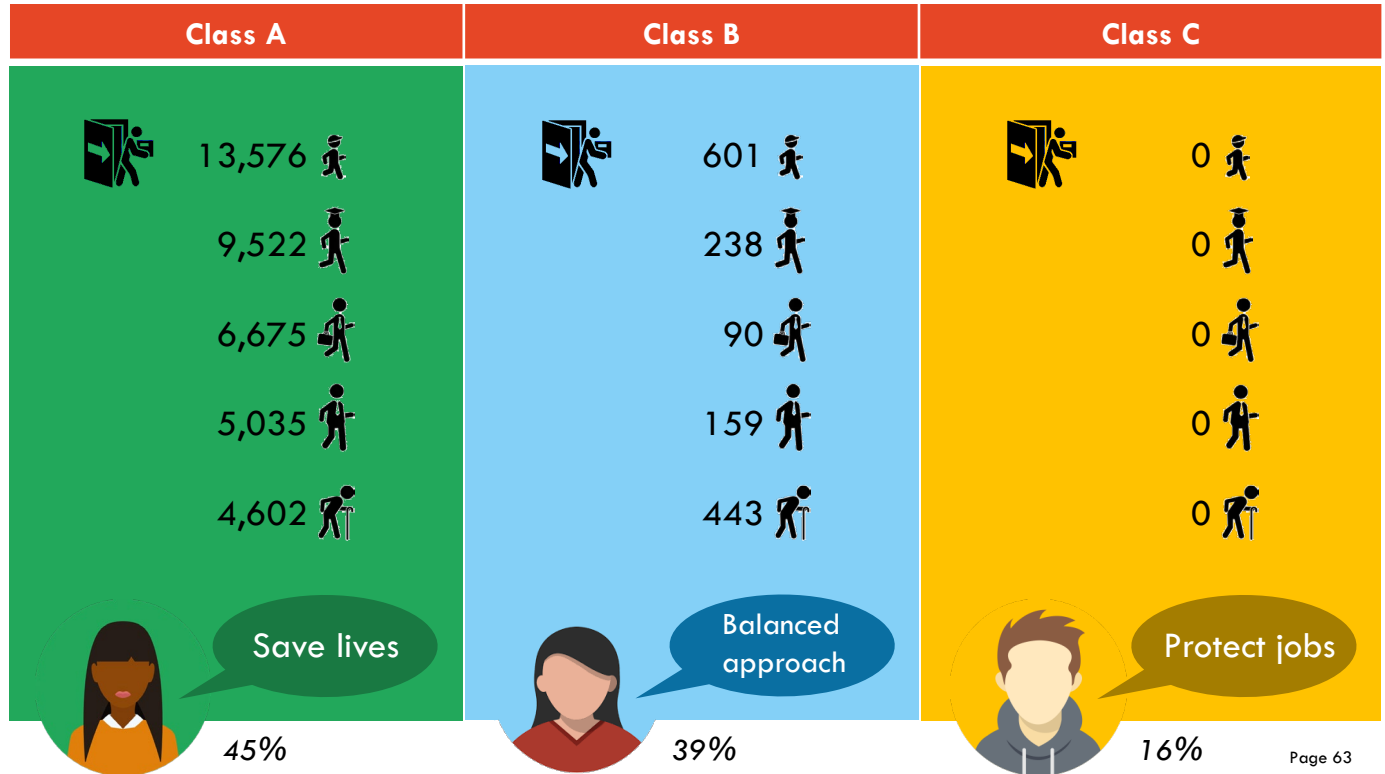
# Application 3: Pandemic policy choice

Willingness to accept job losses to save one life (average over all age groups)



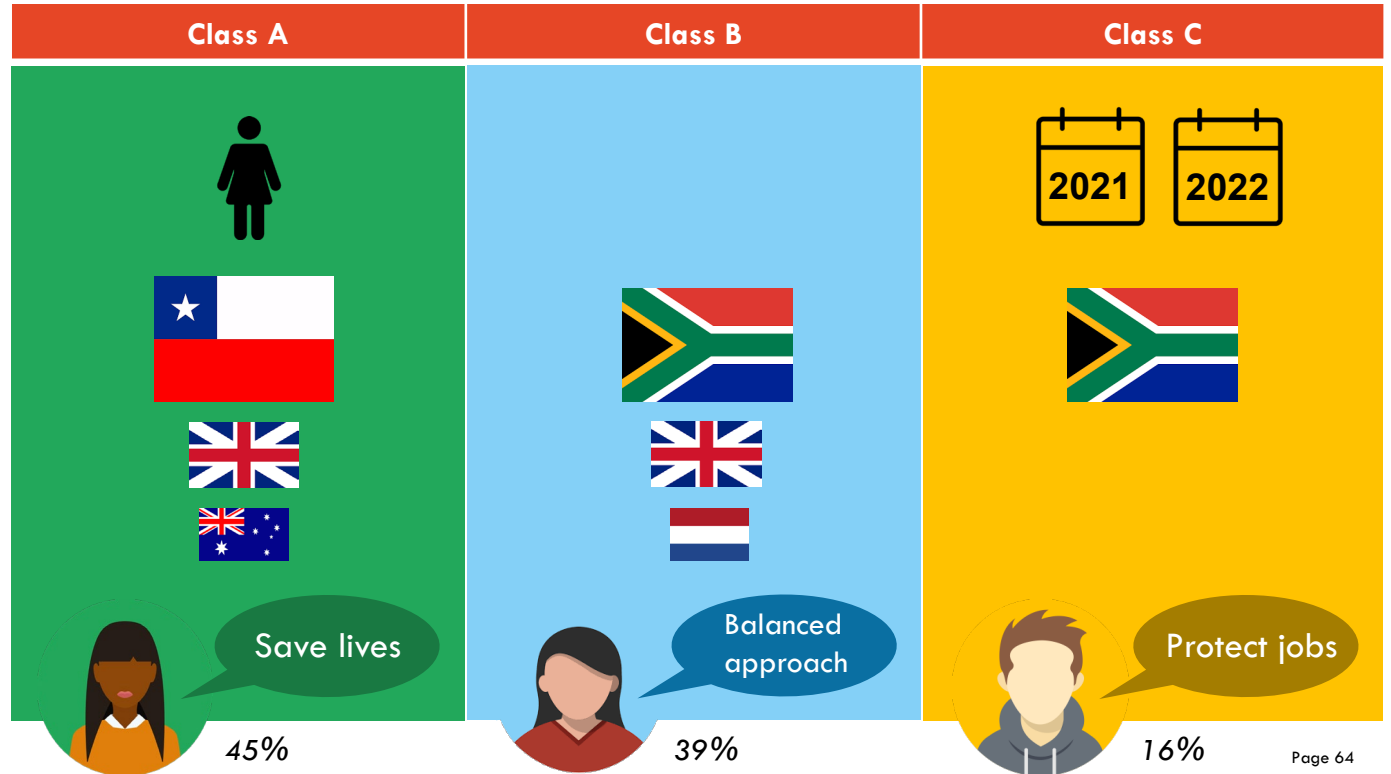
# Application 3: Pandemic policy choice

Willingness to accept job losses to save one life (per age group)



# Application 3: Pandemic policy choice

## Relative likelihood of belonging to a certain class



# Final remarks



# Final remarks

## Used software tools

– Experimental design



– Generation of candidate set



– Survey instrument



– Pictogram creation



– Model estimation



– Analysis and interpretation



# Final remarks

**Choice experiments can be applied in many disciplines**

- Potential for collaboration with UWA researchers?



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