4. Stated preferences methods

A. Contingent valuation

B. Choice experiments

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B. Choice Experiments

- DCE is an attribute-based survey method for exploring preferences, measuring benefits (utility) and assessing economic values.
- Respondents are presented with hypothetical scenarios (choice sets). The choice sets comprise two or more alternatives, which vary along several characteristics or attributes of interest and individuals are asked to choose one alternative.
- Most commonly, each respondent faces several choice questions within a single survey, drawn from statistical design principles.
- DCE originates in the market research and transport literature and more recently has been applied to environment and risk valuation.

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Example of Choice Scenario
(Brouwer et al., 2016)

	Option A	Option B	Current situation
Flood frequency	Once every **25 years**	Once every **50 years**	Once every **5 years**
Water quality	Good	Very good	Moderate
Increase water bill	**€3 / year**	**€10 / year**	**€0**
I prefer:	☐ **Option A**	☐ **Option B**	☐ **Neither**

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Comparing formats: Choice Experiment vs Contingent Valuation

Question X: Do you support the proposal to protect the environment that will ensure:

- an increase in the number of endangered species present from 5 to 10
- an increase in the area of healthy native vegetation from 1500 ha to 1800 ha
- an increase in the number of visitors from 2000 pa to 3000 pa

to be funded by a one-off levy of $20 on your income tax, or do you oppose it?

Please circle the option that most closely represents your view:

I support the proposal with a $20 levy 1
I oppose the proposal and the $20 levy 2

Figure 3.1 Typical contingent valuation method question

Question Y: Consider carefully each of the following three options. Suppose these options were the only ones available, which one would you choose?

Alternative Attribute	'Status Quo' alternative	Proposed alternative 1	Proposed alternative 2
Number of endangered species	5	15	15
Hectares of healthy native vegetation	1500	1800	2100
Visitor days per annum	2000	3000	2000
Cost to you ($)	0	20	10

Please circle your preferred option.

I would choose the status quo at no cost to me................ 1
I would choose alternative 1 at a $20 cost to me............. 2
I would choose alternative 2 at a $10 cost to me............. 3

Figure 3.2 Choice modelling choice set

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Choice Experiments

DCE can provide us with useful insights in risk valuation research:

1. which **attributes are significant determinants** of the values people place on risk mitigation options;
2. the implied **ranking of these attributes** among population;
3. the **total economic value of each attribute and of the a good as a whole**

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Choice Experiments: Design Stages

Design stages in a choice experiment:

1. Selection of attributes
2. Assignment of levels
3. Choice of experimental design
4. Construction of choice sets
5. Data analysis

Software: SPSS, SAS, GAUSS, R, NGene.

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1. Selection of attributes

- This stage involves identifying the **relevant attributes** of the good to be valuated:
  - those thought to **have an effect on the individuals choice** behavior related to that good;
  - those which can be **impacted by a policy option**.
- This is usually done through literarature reviews, pilot studies, focus groups, experts consulations, etc.
- A **monetary cost** (payment vehicle) should be one of the attributes, to allow the estimation of WTP (price needs to be realistic and credible).
- Restrict the number of attributes for a design to a small one (4, 5 or 6). This is because the minimum required sample size increases exponentially in the number of attributes.

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2. Assignment of levels

- It involves the assignment of **realistic levels** for the attributes:
  - "bracket" the existing level of an attribute with higher and lower values;
  - maximum and minimum levels can be identified by scientists and policymakers;
  - the "do nothing" or status quo level should be included.
- Relevant price ranges could be estimated from pilot studies, literature and focus groups. They have to be commensurate with the levels of the attributes.
- Too low prices will always be accepted (small/zero price coefficient); too high prices will always be rejected (as above).

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3. Choice of Experimental Design

- Complete factorial design: a factorial design combines **every level of each attribute with every level of all other attributes**. Each combination of attribute levels is an alternative.
- By considering all the possible combinations it would be possible to ***generate n. levels to the power of n. attributes*** alternatives.
- A problem of the full factorial design is that a **large number of alternatives are generated** as the numbers of attributes and levels are increased.
- Take as an example a choice experiment with **4 attributes and 3 levels**.
- The possible number of alternative is **3^4 = 81**. It is difficult to ask respondents to consider 81 alternatives! Excessive cognitive burden is required.

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Experimental Design types

- Statistical experimental designs provide the means to **select subsets of the total set of possible alternatives (e.g. 81 ⇒ 9)** for use in an experiment (or questionnaire) in a statistically efficient manner: Fractional factorial design.
- Experimental designs were originally developed in the field of experimental science and agricultural research.
- The design has the property of **orthogonality**: each of the variables has zero correlation with any of the others. It means that the influence of changes in any of these attributes on the respondents' choice can be identified and measured.
- Possible to estimate **efficient designs** (according to different criteria, e.g. minimizing variance of estimated parameters)

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4. Construction of choice sets

- You need to **package the alternatives** selected by the experiment design in **choice sets** in order to present them to respondents.
- Usually, the n. of choice sets produced by experimental design can **still be too large** for respondents to be able to cope with ⇒ split them into **"blocks"** and to offer for each respondent only one block.
- How many choice tasks the respondent can be asked to perform? It depends partially on the complexity of the issue itself.
- The **fewer the n. of attributes and levels**, the **higher the number of choice sets** for each person.

4. Construction of choice sets: synthesis

1. Total number of possible alternatives (**e.g. 1000**)
2. Selection of the subset of alternatives via fractional factorial design (**e.g. 100**)
3. Grouping alternatives in choice sets (**e.g. 25 choice sets with 4 alternatives each**)
4. Blocking choice sets (**e.g. 5 blocks with 5 choice sets each**)

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5. Data Analysis

- CE has two "foot-holds" in economic theory:
  1. Lancaster's characteristics theory of value (Lancaster, 1966).
  2. Random Utility Maximization (RUM) (McFadden, 1973).

- Within RUM, an individual's preferences can be represented by the following utility function:

$$U = U(X_1, \ldots, X_m)$$

- which depends on the levels of X = 1, … , n attributes.

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5. Data Analysis

- Many of these elements X are **unobservable** to the researcher or are observable with an error.
- The conventional utility **function U(.)** can be broken down into two parts:
  1. one **deterministic** and **observable** V(.)
  2. an **error term** ε(.):
     - $U = U(X_1, \ldots, X_m) = V(X) + \varepsilon(X)$
- **Advantage**: it is a more realistic representation of preferences
- **Disadvantage**: some assumption have to be made about the nature of error component to make any predictions from this theory, since the error is not observable.

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5. Data Analysis

- Consider an individual being asked to **choose between 2 alternative goods**, which are assumed to be **differentiated by their attributes** and levels (i.e. 2 alternative risk management strategies).
- In choosing between them (2 alternatives g and h) the **respondent is assumed to compare the utility** he/she could get with either choice and then **select the alternative with highest utility**.
- An **error term is introduced** because the respondents may assess the options according to information other than that shown.
- Given that there is an error component in the utility function used, predictions cannot be made with certainty: **the analysis becomes one of the probabilistic choice**.

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5. Data Analysis

- The probability that a respondent ***i*** prefers option ***g*** in the choice set to any alternative option ***h*** can be expressed as the **probability that the utility associated** with option ***g*** exceeds that associated with all other options.

$$P(U_{ig} > U_{ih}) = \frac{\exp(\mu V_{ig})}{\sum_j \exp(\mu V_{ij})}$$

$$P(choose_g) = \frac{\exp(\beta' X_{ig})}{\sum_j \exp(\beta' X_{ij})}$$

X = vector of attributes
β = vector of estimated coefficient
μ = scale parameter (usually is set to 1)

- If the dependent variable takes only two possible values (ex. A or B) then a **binary logit model** is required, if it takes 3 or more values (ex. A, B, neither) then a **multinomial logit** model is required.

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5. Data Analysis

- Discrete choice models explain selection amongst alternatives: they allow one to obtain information on probabilities of selection of a given alternative from the set of alternative available to respondents.
- Selection probabilities are made a function of attributes and possibly of selected individual's characteristics.
- Differences in taste and the ignorance of the researcher about the taste structure of the agents are captured by an error component (or unobserved utility) stochastically distributed Gumbel.
- McFadden is credited with the complete formal derivation of the commonly employed Multinomial logit model (Nobel Price - 2000).
- **Discrete choice models**: Multinomial Logit Model (MNL) and other specifications (Mixed Logit Model, Latent Class Model, …)

5. Data Analysis: Estimation of a MNL model and WTP values

(From Brouwer et al., 2016)

	Option A	Option B	Current situation
Flood frequency	Once every 25 years	Once every 50 years	Once every 5 years
Water quality	Good	Very good	Moderate
Increase water bill	€3 / year	€10 / year	€0
I prefer:	☐ Option A	☐ Option B	☐ Neither

WTP = 0.008/-(-0.064) = €0.125

Variable	Coeff. estimate	St. error
ASC	-2.034^{***}	0.334
Choice attributes		
FLOOD RISK	0.008^{***}	0.003
GOOD QUALITY	2.108^{***}	0.376
VERY GOOD QUALITY	2.686^{***}	0.413
PRICE	-0.064^{***}	0.013

$$WTP = \frac{-b_c}{b_y}$$

Where b_y is the cost coefficient and b_c is the coefficient of any of the attributes.

These ratios are known as implicit prices and show WTP for a change in any of the attributes.

Advantages of Choice Experiments

- CE can be seen as a natural generalization of CV. **A CV study (change or no change) cannot value the attributes of the change** (or the attributes of the policy leading to the change). CE, because they look at more than two alternatives, provide a natural way to do it.
- CE do a better job than CV in measuring the **value of changes in the characteristics of goods**. This is a more useful focus from a management/policy perspective than focusing on either the gain or loss of the good.
- CE may avoid some of the response issues in CV: i.e. yea-saying.

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Disadvantages of Choice Experiments

- In order to estimate the value of a good, as distinct from a change in one of its attributes, it is necessary to assume that the value of the whole is equal to the sum of the parts.
- But:
  - there may be additional attributes not included in the design which generate utility
  - is the value of the whole indeed linear additive?
- Value estimates of CE are sensitive to study design.
- Choice complexity can be a problem for the respondents.

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Case study:

Valuing landslide risk reduction programs in the Italian Alps
(Mattea, Franceschinis, Scarpa, Thiene, 2016)

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Motivation

Climate change has increased the frequency and intensity of weather-related natural hazards

Mountain areas with dense human settlements (Italian Alps) suffer the costliest consequences from landslides

↓

Need of preference analysis of local residents for risk reduction programs to inform the design of mitigation policies

↓

Choice experiment (CE)

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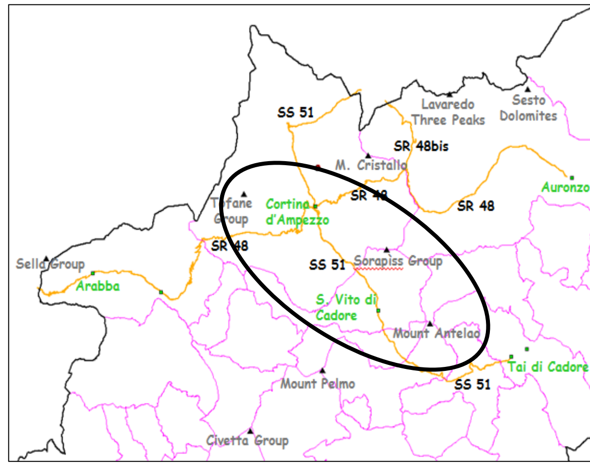
Case study: Boite Valley (Belluno)

<u>High hydrogeological risk level</u>

Notable past events:

- 1814: destruction of two villages, 257 victims
- 1925: 288 victims, 53 people went missing
- 2009: 2 victims, significant damage to properties
- 2015: 3 victims, 8 events, road damage



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CE Attributes (safety devices) and levels

Attribute	Description	Levels
Channel	Diverging channel is a man-made channel built to redirect water.	1 if present 0 otherwise
Basin	Retaining basin is a dam where the solid and liquid mass is collected prior to damage roads and villages.	1 if present 0 otherwise
Video cameras	Video cameras monitor the debris-flow during the night and, in case of emergency, they will activate the alarm system and the traffic lights on the road.	1 if present 0 otherwise
Acoustic sensors	Acoustic sensors detect soil movement in slopes prior to landslides and provide an acoustic signal to give early warnings of landslide occurrence.	1 if present 0 otherwise
Road toll	A road toll to pay for eight months (from April to November of a specific year) daily for transit in the valley by car for residents and tourists.	€1 €2 €3 €4

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Example of choice scenario

Safety devices	A	B	C	D	E	F	Status quo
Channel	-	-	-	channel	channel	channel	-
Basin	-	basin	basin	basin	-	-	insuff. basin
Video cameras	video	-	video	-	-	video	-
Acoustic sensors	-	-	sensors	-	sensors	sensors	-
Road toll	€2	€1	€4	€2	€3	€3	€0
Your choice	◯	◯	◯	◯	◯	◯	◯

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Aims of the study

General research question (Q1):

Evaluate preferences towards different safety devices designed to increase protection from potential debris-flow in the Boite Valley

Specific research questions:

1. (Q2) How does information affect respondents' preferences?
2. (Q3) How are WTP estimates spatially distributed?

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Information effect

- Research hypothesis: providing information for an attribute increases its perceived benefits.
- Framework:
  1. **Data collection (N = 250 residents and visitors of the Valley)**:

First sequence of choice sets

↓

Information provision

↓

Second sequence of choice sets

  2. **Econometric analysis of choice data**

Mixed Logit model in WTP space

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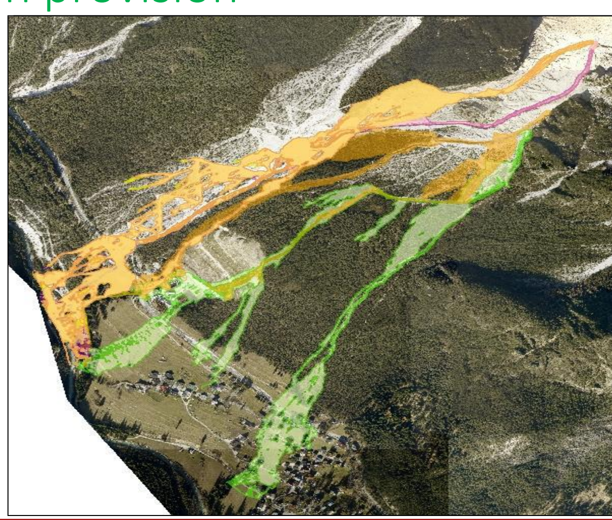
Information provision

Two hydro-geological simulations of debris-flows:

i) All possible trajectories of debris-flows in three sites of the Valley.

ii) Debris-flow trajectories in a specific site **with and without a channel**.



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Results – Choice model estimates (Q1 & Q2)

	Value	Std. Err.	p-value
Mean parameters			
μ BAS	1.83	0.36	<0.001
μ CHAN	2.12	0.47	<0.001
μ SENS	1.26	0.21	<0.001
μ VIDEO	1.19	0.29	<0.001
μ ASC_SQ	−1.98	0.97	<0.001
μ ln(λ)	−2.05	1.12	<0.001
Interaction parameters			
Info × BAS	0.13	0.16	0.24
Info × CHAN	0.42	0.20	<0.001
Info × SENS	0.34	0.31	0.19
Info × VIDEO	0.08	0.14	0.56
Info × TOLL	0.04	0.24	0.81
Info × ASC_SQ	−0.15	0.09	0.03
Standard deviation parameters			
σ BAS	1.21	0.35	<0.001
σ CHAN	1.36	0.38	<0.001
σ SENS	0.99	0.41	<0.001
σ VIDEO	1.01	0.58	<0.001
σ ASC_SQ	0.87	0.63	<0.001
σ ln(λ)	1.81	0.95	<0.001
Log-likelihood	−2402.88		

Perceived benefits for all devices (passive > active)

Positive effect of information on WTP for channel

High variation of preferences towards devices

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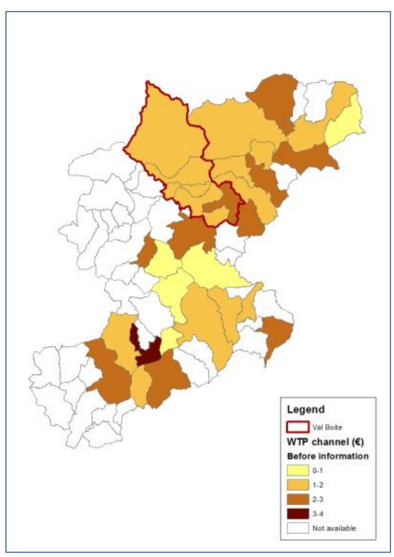
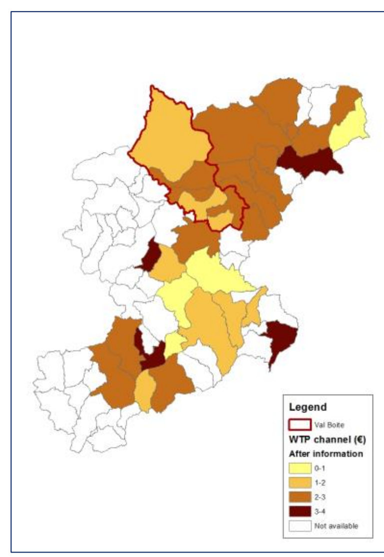
Maps of the WTP for channel (before & after information treatment) (Q3)





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Implications

- Main results:
  - Variation of preferences towards safety devices;
  - Visitors and residents are willing to pay for all devices;
  - Information increases WTPs.
  - WTPs are spatially heterogeneous.

- Informing citizens and accounting for spatial distribution of benefits may induce a broader acceptance of public intervention.

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