Testing axioms of stochastic discrete choice using population choice probabilities

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Background, definitions

- $P_A(x)$ is the probability that an individual drawn from a population chooses item x when presented with finite choice set A.
- A *random choice structure* for a master set T specifies $P_A(x)$, all $x \in A \subseteq T$.
- Δ is the set of all random choice structures on T.
- Falmagne (1978): A random choice structure P can be induced by a random utility model iff for all $x \in A \subseteq T$,

$$\sum_{B:\, A \subseteq B \subseteq T} (-1)^{|B \setminus A|} P_B(x) \geq 0.$$

- Let Λ be the set of random choice structures satisfying random utility; we will test the hypothesis $P \in \Lambda \subset \Delta$ against $P \in \Delta$.

Broad research questions

Looking across a wide variety of choice environments,

1. what regions of Δ outside Λ are empirically relevant?
2. are some subregions of Δ more empirically relevant than others?

Notes:

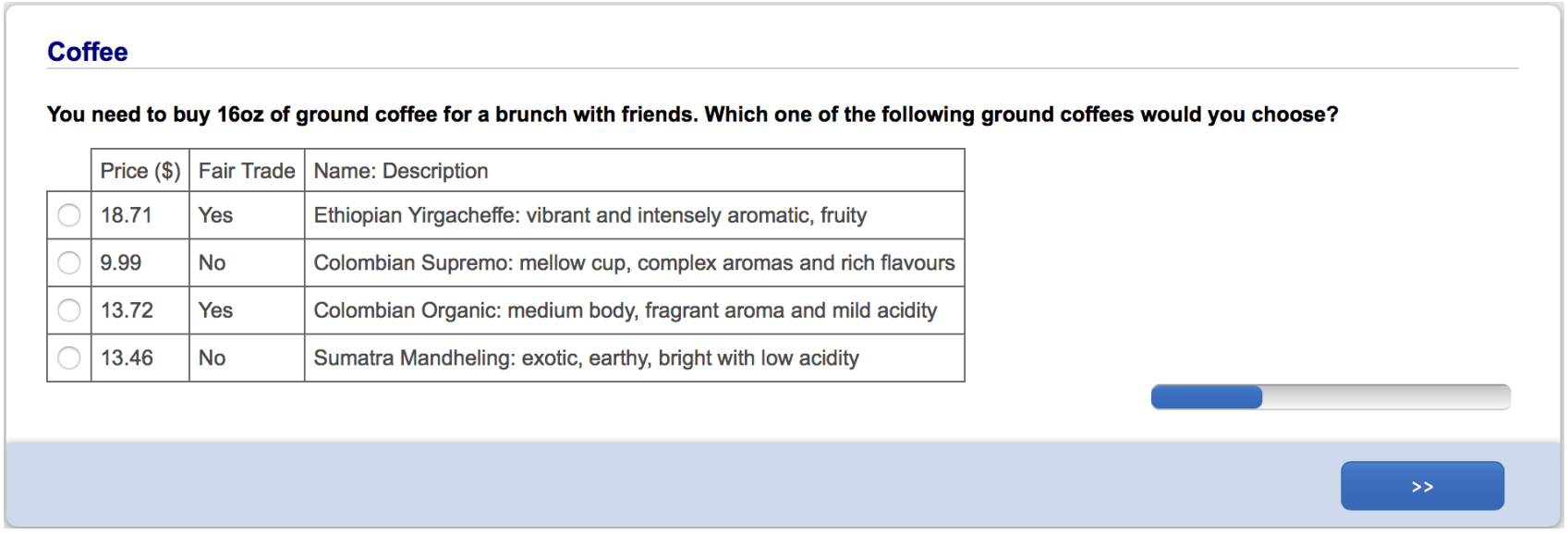
- We are interesting in answering these for two kinds of choice probabilities: individual and population.

A new discrete choice experiment

We designed and ran an experiment with these features:

1. There is a wide variety (32 in total) of choice domains, each with a master set of size five.
   - to say something general about choice
2. We present all doubleton and larger subsets of each master set, each one to 40 different participants.
   - to expose all implications of random utility (and other conditions) to possible falsification,
3. Each participant sees exactly one choice set from each domain.
   - to be confident that choices are independent (globally) and identically distributed (choice set by choice set).

A consumer choice example



Coffee

You need to buy 16oz of ground coffee for a brunch with friends. Which one of the following ground coffees would you choose?

	Price ($)	Fair Trade	Name: Description
○	18.71	Yes	Ethiopian Yirgacheffe: vibrant and intensely aromatic, fruity
○	9.99	No	Colombian Supremo: mellow cup, complex aromas and rich flavours
○	13.72	Yes	Colombian Organic: medium body, fragrant aroma and mild acidity
○	13.46	No	Sumatra Mandheling: exotic, earthy, bright with low acidity

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Figure 1: Coffee

A judgement example

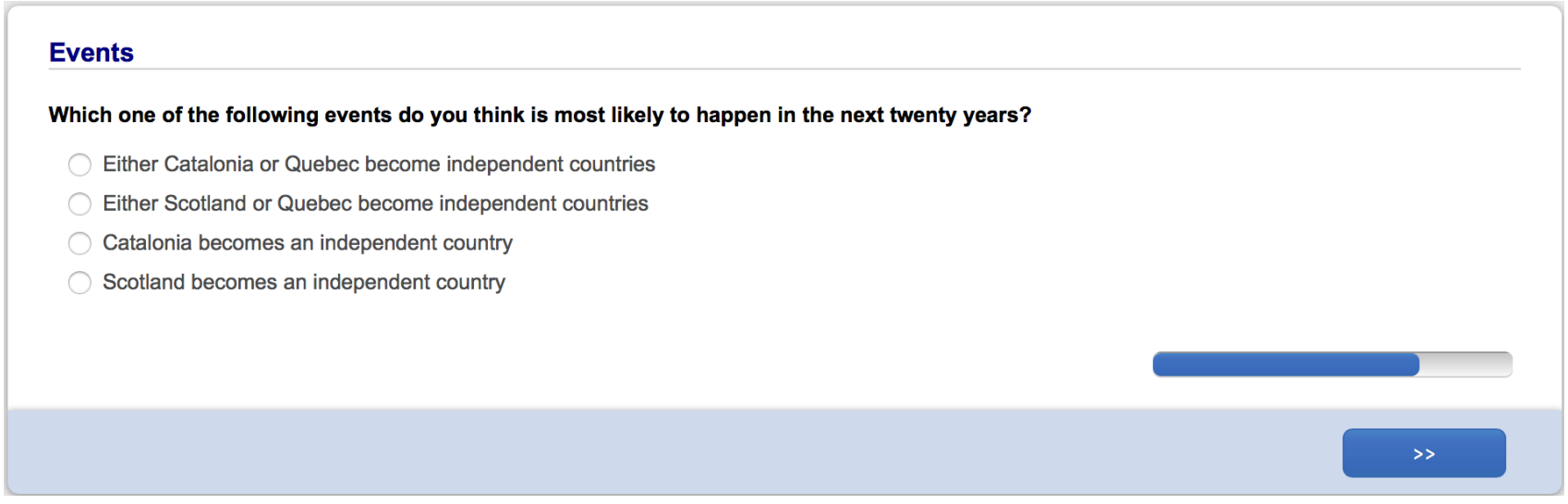

Figure 2: Events

A visual example

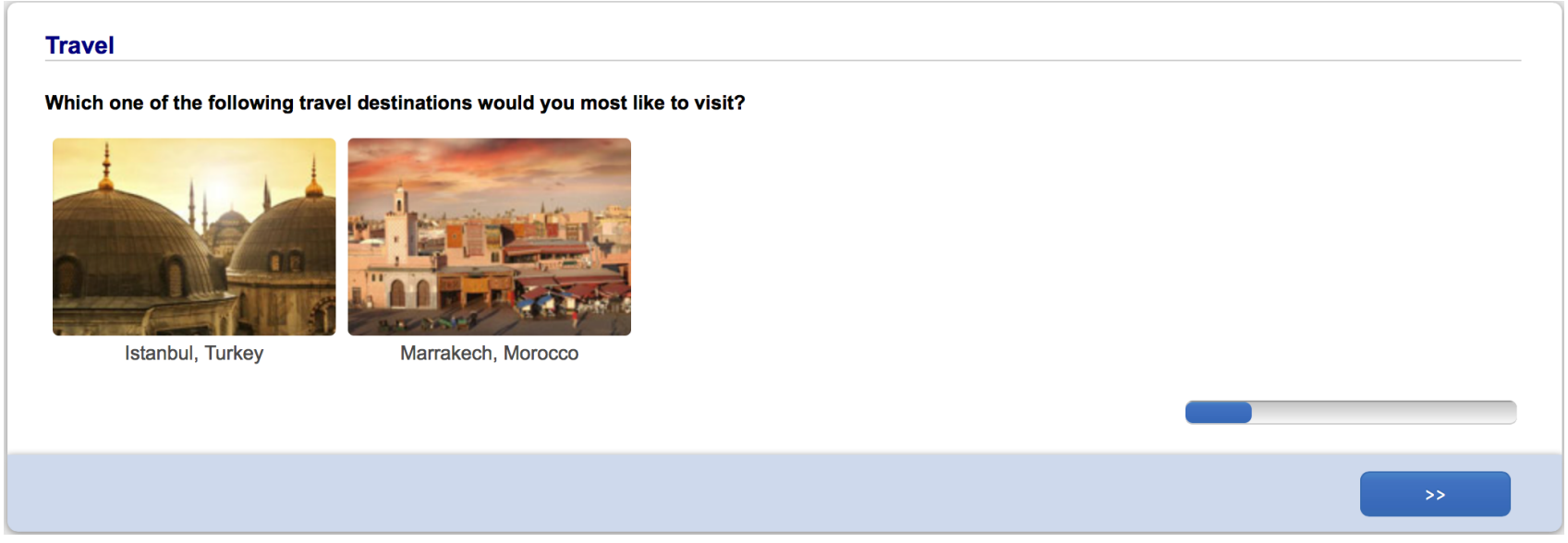

Figure 3: Travel

Assignment of subjects to choice sets

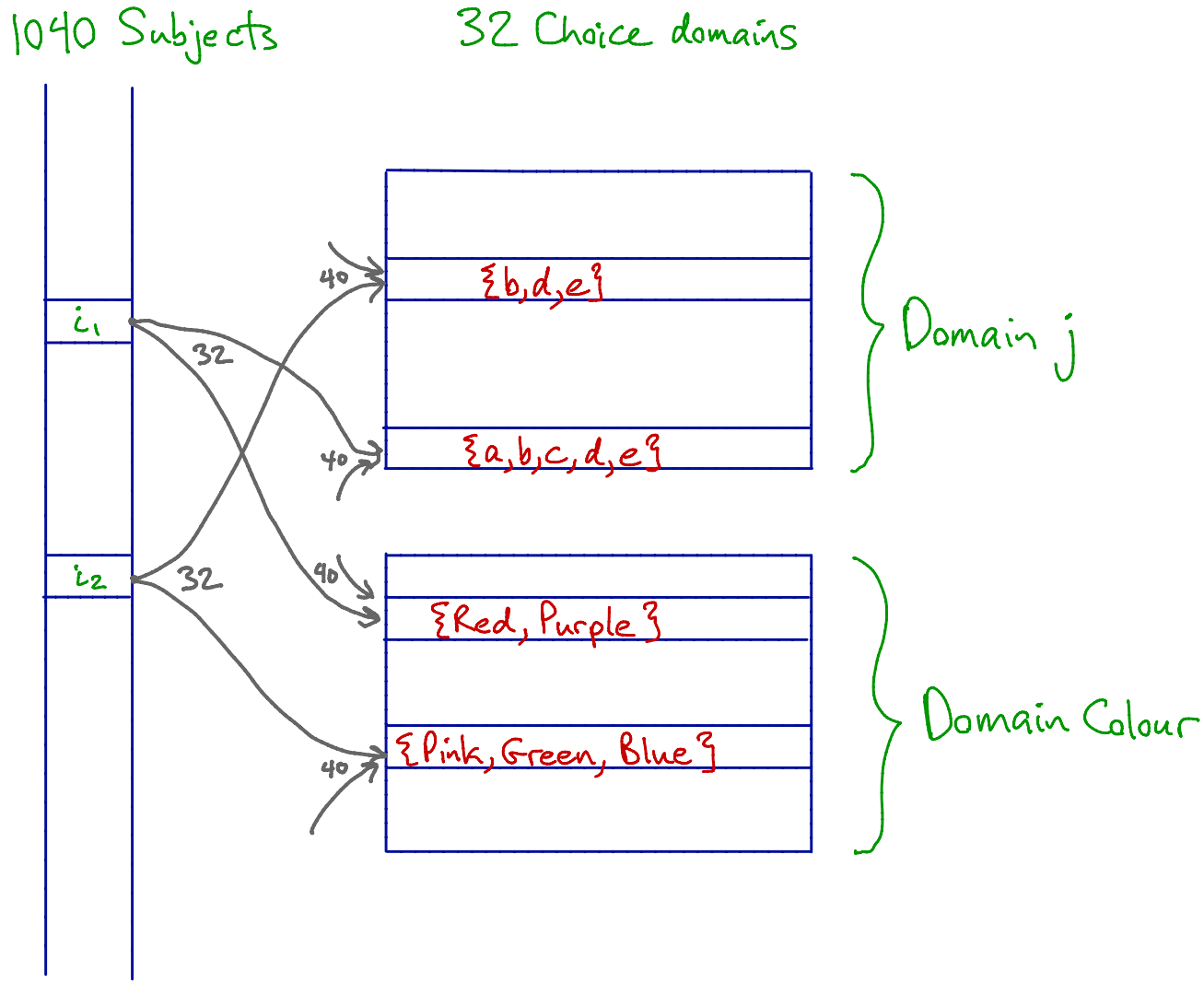

Figure 4: Assignment of subjects to choice sets

Testing conditions on P using Bayes factors

Definitions:

- Λ is the region where random utility (or some other condition) holds.
- Y is data, y the observed data.

The Bayes factor in favour of the restricted model against the encompassing model is

$$\mathrm{BF} \equiv \frac{\Pr[Y = y | P \in \Lambda]}{\Pr[Y = y]} = \frac{\Pr[P \in \Lambda | Y = y]}{\Pr[P \in \Lambda]}.$$

Log Bayes factors, first 16 domains

	WST	MST	SST	Reg	RU	MI
Male stars	0.4	2.2	4.2	1.8	1.5	6.3
Female stars	0.0	0.5	1.3	1.2	0.8	2.5
Films	-0.7	-0.9	-2.2	1.6	1.4	6.8
Star pairs	0.1	0.0	-0.7	1.8	1.7	3.9
Pizzas	-0.4	-1.5	-Inf	1.7	1.4	3.9
Juices	0.1	0.5	0.1	1.5	1.3	5.8
Colours	0.2	1.6	1.3	1.3	1.1	5.3
Colour Combinations	-1.1	-2.3	-3.6	1.7	1.5	5.2
Events	0.2	1.4	0.1	0.7	0.7	2.9
Radio formats	0.4	1.9	3.3	0.8	0.6	5.4
Musical artists	0.1	1.0	1.5	1.9	1.6	6.0
Aboriginal art	0.3	1.3	2.7	1.2	0.9	1.4
Impressionist art	0.3	1.5	2.4	1.5	1.2	4.9
Sentences	0.2	1.5	0.9	1.6	1.4	6.6
Travel	0.4	2.1	4.1	1.5	1.3	6.9
Marijuana	0.4	0.1	-3.6	1.5	1.4	3.6

Log Bayes factors, other 16 domains

	WST	MST	SST	Reg	RU	MI
Latitude	0.4	1.5	-Inf	0.6	0.5	-Inf
Dots	0.2	1.0	1.5	1.8	1.5	5.1
Triangles	0.0	0.9	0.8	1.2	1.0	-Inf
Population	-0.1	0.0	0.3	1.9	1.6	6.0
Surface area	0.4	1.5	4.3	1.5	1.5	5.3
Beer	-0.1	0.7	1.6	0.6	0.6	2.5
Cars	0.0	0.2	-0.2	1.1	1.0	4.4
Restaurants	0.1	0.9	0.3	0.7	0.6	3.5
Flight layovers	0.4	0.6	0.6	1.2	1.1	-Inf
Future payments	0.4	1.1	0.3	1.7	1.7	-Inf
Phone plans	-1.1	-1.9	-1.3	1.0	0.8	1.4
Hotel rooms	0.5	1.9	2.9	1.2	1.0	3.7
Two-flight itineraries	-0.5	-0.9	-1.1	1.4	1.1	2.8
Televisions	0.5	2.4	3.5	1.6	1.4	5.0
Coffee	0.3	1.9	2.8	1.6	1.4	6.7
Charity	0.2	-0.6	-Inf	0.9	0.8	1.4

Conclusions

1. For each choice domain, random utility is favoured, although never strongly.
2. Overall evidence in favour of random utility is compelling.