Modeling demand for electric vehicles: the effect of car users' attitudes and perceptions

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Outline

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Introduction & motivation

Current situation:

- Search for ecological alternatives to fossil fuels:
    - Alternative fuel vehicles (LPG, CNG, etc.)
    - Electric vehicles (EV) being released

Collaborative project with Renault:

- Renault launches Zero Emission (Z.E.) product line (4 products) soon (2011-2012)

Twizy
≈ Urban vehicle

Zoé
≈ Clio

Fluence Z.E.
≈ Mégane

Kangoo
≈ Fleet vehicle

Introduction & motivation

The **electric vehicle**

- No CO_2 emissions
- No noise
- 185 km range
- 8h to charge battery completely
- Restricted charging locations

Variables that can influence **people's purchase choices.**

Introduction & motivation

Objective of research project:

- Analysis of **demand for electric vehicles** for **private use**

Research steps:

1. Design of stated preference survey: **hypothetical choice situations**

    - Classical vehicles (petrol, diesel, etc.)
    - Electric vehicles (from Renault Z.E. product line)

    Zoé   Fluence Z.E.

2. Application of **discrete choice methodology**
3. **Forecasting** of market shares

Introduction & motivation

Objective of research project:

- Analysis of **demand for electric vehicles** for **private use**

Research steps: **Focus of this talk**

1. Design of stated preference survey: **hypothetical choice situations**

    Classical vehicles (petrol, diesel, etc.)
    Electric vehicles (from Renault Z.E. product line)

    Zoé   Fluence Z.E.

2. Application of **discrete choice methodology**
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Introduction & motivation

Research issues raised:

- **Design of survey:** choice situations close to reality

- **Modeling:** develop discrete choice models to evaluate **demand for EV**:
  - Identification of **target customers**
  - Identification of **ideal pricing** of EV: i.e. analyze impact on choice of:
    - Vehicle price
    - Costs of usage
    - Battery lease
    - Potential governmental incentive
  - Assessment of the impact of **attitudes** and **perceptions** on choice

- **Forecasting:** predict in realistic way the **market shares of EV** and classical vehicles among the **target population of new buyers** in Switzerland

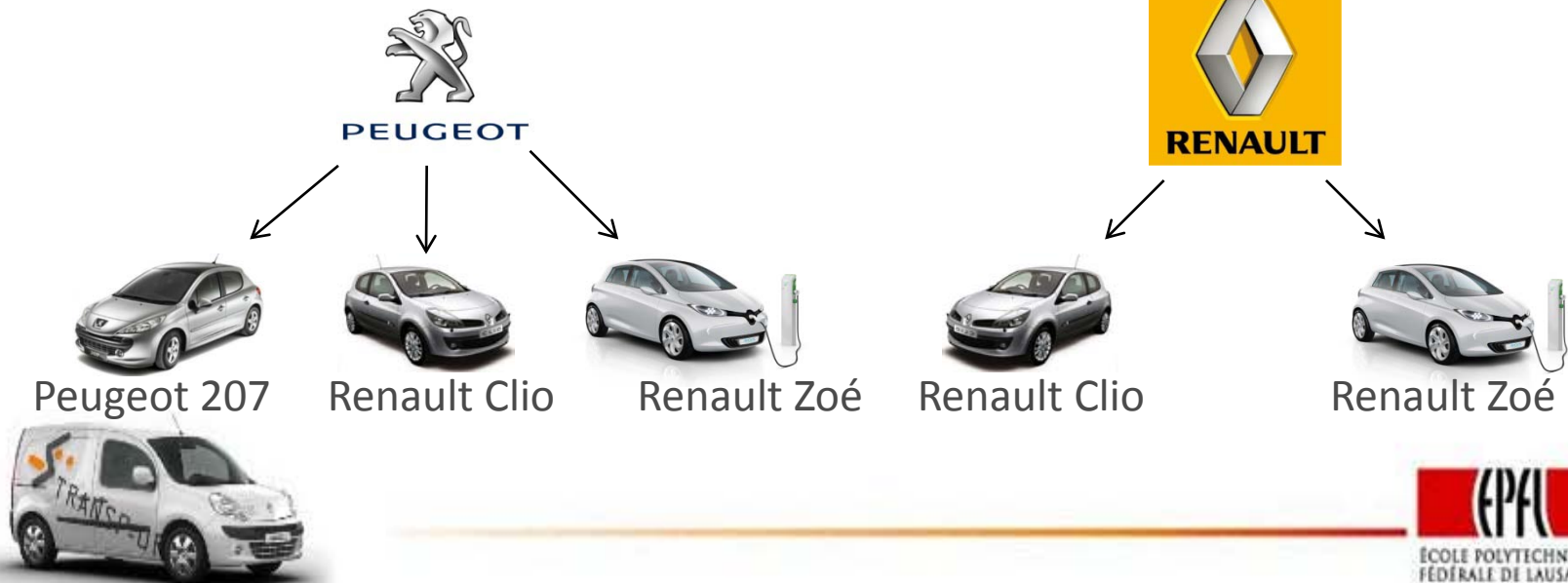ÉCOLE POLYTECHNIQUE
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Data collection: type of survey

Type of survey: **stated preference (SP)** survey

- **Hypothetical** choices between
  - Current vehicle of respondent
  - Analogous model in Renault product line
  - Analogous model in Renault Z.E.

Reason: EV not yet on market

Peugeot 207   Renault Clio   Renault Zoé   Renault Clio   Renault Zoé

Data collection: sample

5 types of respondents sampled in Switzerland:

- Recent buyers
- Prospective buyers
- Renault customers
- Pre-orders
- Newsletter
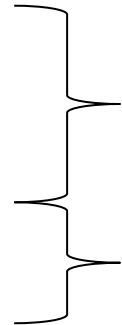
Sampling protocol → representativity from:

- 3 language regions of Switzerland (German, French, Italian)
- Gender
- Age category (18-35 years, 36-55 years, 56-74 years)

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Data collection: sample

5 types of respondents sampled in Switzerland:

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Sampling protocol

All available

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Data collection: structure of survey

2 phases:

- **Phase I:**
  - Characteristics of respondent's car(s) → **Creation of choice situations**
  - Socio-economic information
  - Mobility habits

- **Phase II:**
  - Opinions on topics related to EV
  - Perceptions of four categories of EV
  - Choice situations

Data collection: structure of survey

2 phases:

- **Phase I:**
  - Characteristics of respondent's car(s)
  - Socio-economic information ⟶ **Segmentation, identification of potential users**
  - Mobility habits

- **Phase II:**
  - Opinions on topics related to EV
  - Perceptions of four categories of EV
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Data collection: structure of survey

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- **Phase I:**
  - Characteristics of respondent's car(s)
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  - Mobility habits ⟶

- **Phase II:**
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  - Perceptions of four categories of EV
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Characterization of mobility of potential users:

- Total distance performed on each weekday

- Total distance performed in the weekend

- Average duration of weekday trips

- Number of cars in the household, etc.

Data collection: structure of survey

2 phases:

- **Phase I:**
  - Characteristics of respondent's car(s)
  - Socio-economic information
  - Mobility habits

- **Phase II:**
  - Opinions on topics related to EV →
  - Perceptions of four categories of EV
  - Choice situations

Evaluation of effect of attitudes on choice:

- Environmental concern

- Attitude towards new technologies

- Perception of reliability of EV

- Importance of design

- Perception of leasing

Data collection: structure of survey

2 phases:

- **Phase I:**
  - Characteristics of respondent's car(s)
  - Socio-economic information
  - Mobility habits

- **Phase II:**
  - Opinions on topics related to EV
  - Perceptions of four categories of EV →
  - Choice situations

Evaluation of effect of perceptions on choice:

- Vehicles with combustion engine
- Hybrid vehicles
- Electric vehicles
- Renault vehicles

Data collection: structure of survey

2 phases:

- **Phase I:**
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  - Socio-economic information
  - Mobility habits

- **Phase II:**
  - Opinions on topics related to EV
  - Perceptions of four categories of EV
  - Choice situations ————→

• **Core of SP survey**

• **5 choice experiments per individual**

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Data collection: structure of survey

An example of choice experiment

Reported by respondent

Characteristics	Your vehicle	Renault vehicle with combustion engine	Renault electric vehicle
Make	Audi	Renault	Renault
Model	A4	Laguna	Fluence
Fuel	Petrol	Petrol	Electricity
Purchase price (in CHF)	42'400	37'200	56'880
Incentive (in CHF)	0	0	−1'000
Total purchase price (in CHF)	42'400	37'200	55'880
OR: Monthly leasing price (in CHF)	477	399	693
Maintenance costs (in CHF for 30'000 km)	850	850	425
Cost in fuel/electricity for 100 km (in CHF)	11.70	13.55	3.55
Battery lease (in CHF per month)	0	0	125

Data collection: structure of survey

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Deduced from segment of owned car

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Obtained from data base of cars currently sold on market

Data collection: structure of survey

An example of choice experiment

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Fixed attributes

Data collection: structure of survey

An example of choice experiment

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Design variables

Data collection: structure of survey

Design variables

EV variable	Level 1	Level 2	Level 3	Level 4
Purchase price	$(P_{own} + 5'000) * 0.8$	$(P_{own} + 5'000) * 1$	$(P_{own} + 5'000) * 1.2$	-
Governmental incentive	- 0 CHF	- 500 CHF	- 1'000 CHF	- 5'000 CHF
Cost of fuel/electricity for 100 km	1.70 CHF	3.55 CHF	5.40 CHF	-
Battery lease	85 CHF	105 CHF	125 CHF	-

Methodology: experimental design

Experimental design:

- Fractional factorial design

- Four-factor interactions confounded ⟶ resolution V

- Blocking with respect to 4 target groups:
    1. Recent buyers
    2. Prospective buyers
    3. Renault customers
    4. Pre-orders
       Newsletter

Methodology: experimental design

Sampling procedure:
1. Selection of **sequences of levels** relative to respondent's **sample group**
2. Sampling **with replacement between individuals**
3. Sampling **without replacement** for choice situations of **each individual**

Sampling weights:
● Correct for **oversampling** of some levels
● Weights computed with **iterative proportional fitting (IPF)**

	Incentive	Price	Fuel cost of 100 km	Battery lease
1	0	0.80	1.70	85
2	0	1.00	3.55	125
3	0	1.00	5.40	105
4	0	1.20	3.55	105
5	-500	0.80	1.70	125
6	-500	1.00	3.55	85
7	-500	1.00	5.40	105
8	-500	1.20	3.55	105
9	-1000	0.80	3.55	105
10	-1000	1.00	5.40	105
11	-1000	1.00	3.55	85
12	-1000	1.20	1.70	125
13	-5000	0.80	3.55	105
14	-5000	1.00	5.40	105
15	-5000	1.00	3.55	125
16	-5000	1.20	1.70	85

Methodology: discrete choice model

- Achieve modeling and forecasting goals
  → use of discrete choice methodology

- Logit model with multiple alternatives
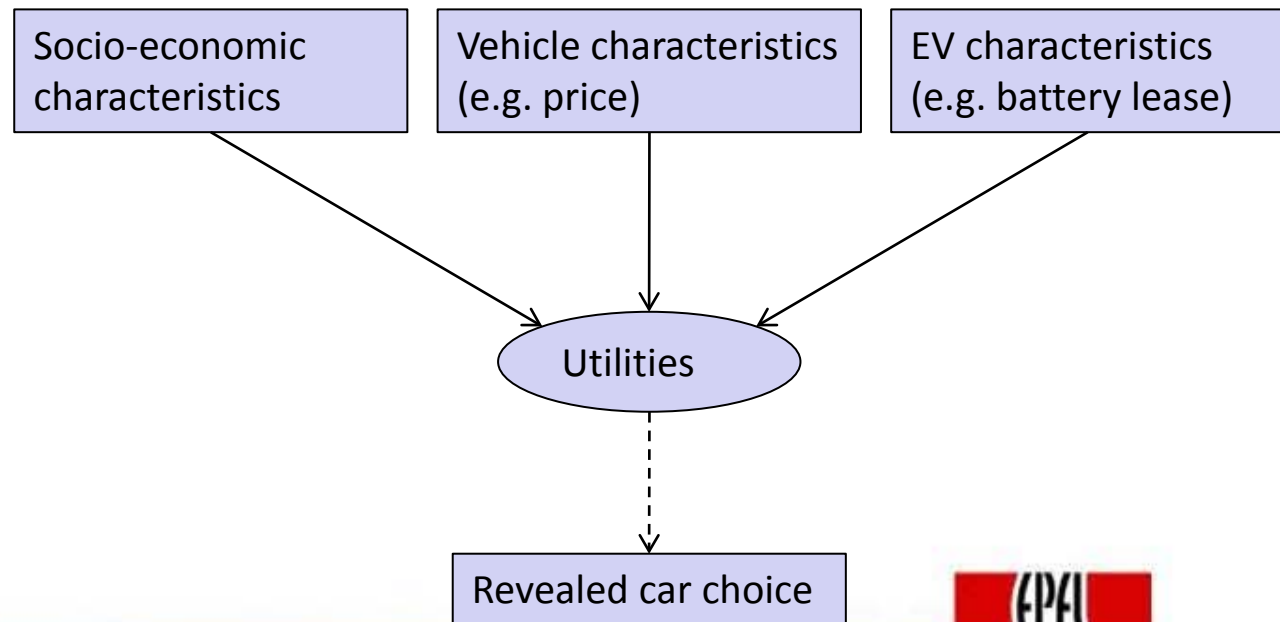
Estimation results

	Gasoline – competitors (GC)		Gasoline – Renault (GR)		Electric – Renault (EV)	
	Estimate	t-test	Estimate	t-test	Estimate	t-test
ASC GASOLINE COMPETITORS	0.439	1.77				
ASC GASOLINE RENAULT			-0.901	-2.46		
PRICE GASOLINE COMPETITORS	-0.0318	-1.89				
PRICE GASOLINE RENAULT			-0.275	-3.78		
PRICE ELECTRIC RENAULT					-0.448	-10.47
COST OF REFUELING (SMALL CONSUMPTION)	-0.0775	-3.52	-0.0775	-3.52		
COST OF RECHARGING BATTERY (HIGH)					-0.21	-2.45
BATTERY LEASE (HIGH)					-0.182	-2.05
INCENTIVE (HIGH)					0.649	7.15
USE PT GAS. COMP.	-0.496	-5.09				
USE PT GAS. REN.			-0.471	-2.43		
FAMILY STATUS GAS. COMP.	-0.251	-2.91				
FAMILY STATUS GAS. REN.			-0.0827	-0.48		
INCOME GAS. COMP.	-0.305	-3.58				
INCOME GAS. REN.			-0.183	-1.1		
CARS HOUSEHOLD GAS. COMP.	-0.237	-4.16				
CARS HOUSEHOLD GAS. REN.			-0.0603	-0.65		
AGE GAS. COMP.	0.202	2.03				
AGE GAS. REN.			-0.141	-0.67		

Estimation results

Price affects negatively utility of 3 vehicles, impact
1) highest for EV
2) second highest for GR
3) lowest for GC

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Cost of refueling: negative effect on choice of gasoline cars with use cost < 15 CHF / 100 km

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Cost of refueling: negative effect on choice of gasoline cars with use cost < 15 CHF / 100 km

Design variables:
1) Negative effect of high charging costs (5.40 CHF)
2) Negative effect of high battery lease (125 CHF)
3) Positive effect of high incentive (5'000 CHF)

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Estimation results

Socio-economic characteristics have meaningful interpretation.

Related to:
- Usage of public transport
- Family status
- Income
- Cars in the household
- Age of respondent

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Conclusion

Model demand for electric vehicles:

Survey:
- Realistic choice context: adapted to respondent

Model:
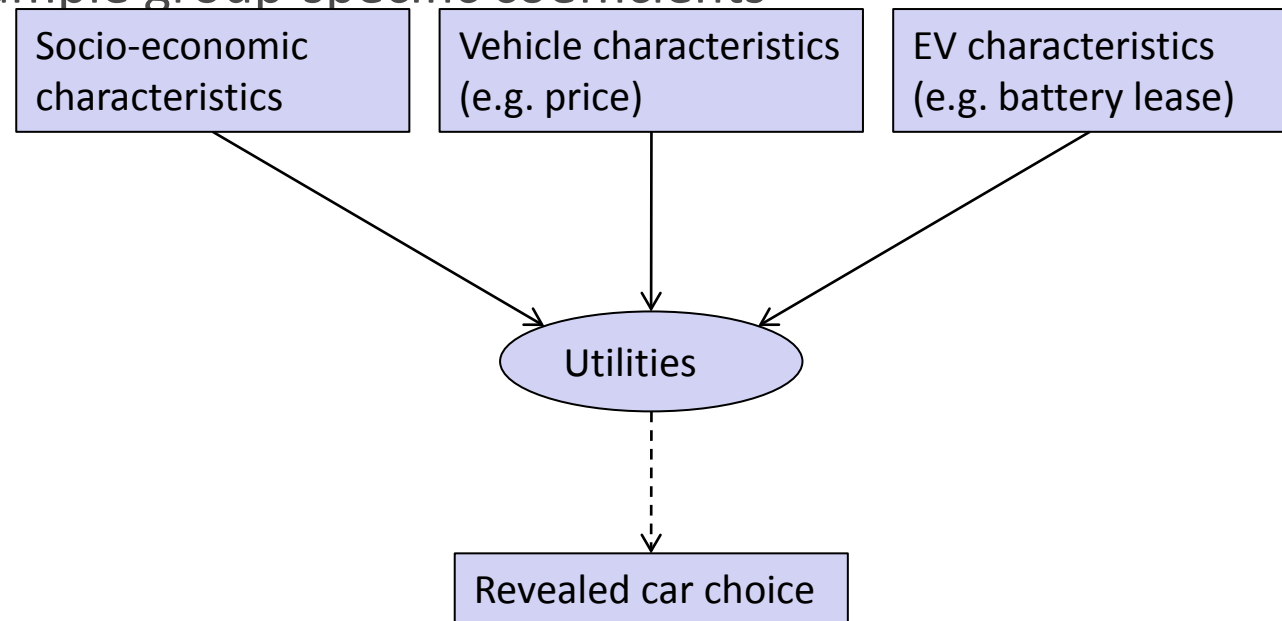- Estimation results with meaningful interpretation
- Assess impact of price characteristics
- Identify target customers

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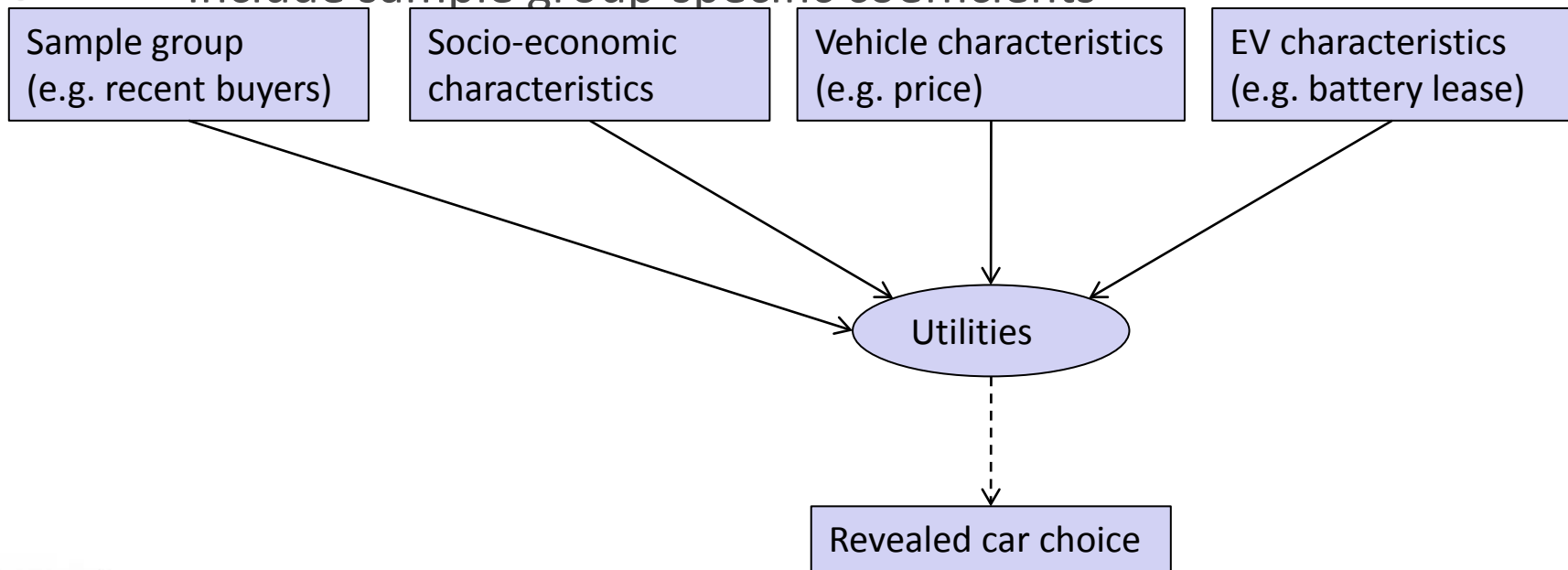FÉDÉRALE DE LAUSANNE

Future works: modeling

Improve specification:

- Segmentation by sample group significant
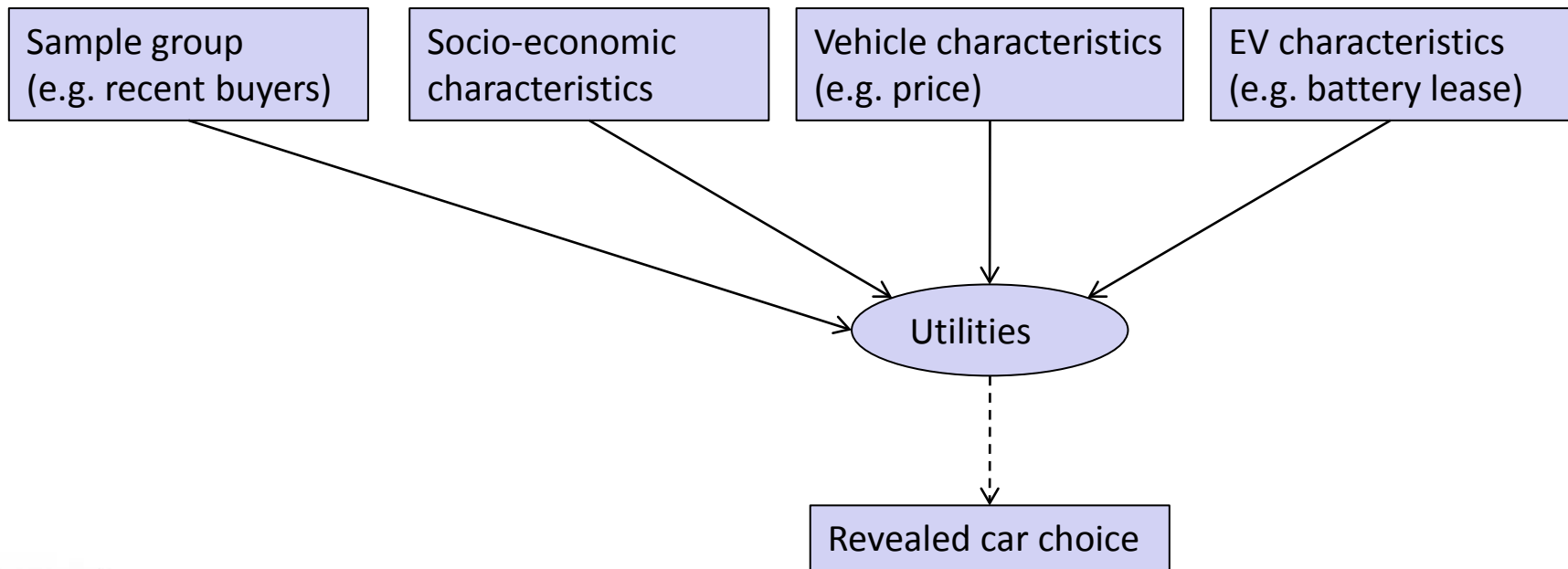- → Include sample group-specific coefficients

Future works: modeling

Improve specification:

- Segmentation by sample group significant
- ➡ Include sample group-specific coefficients

| Sample group (e.g. recent buyers) | Socio-economic characteristics | Vehicle characteristics (e.g. price) | EV characteristics (e.g. battery lease) |

Utilities

Revealed car choice

Future works: modeling

Capture effect on choice of unobserved variables (attitudes, perceptions)

Future works: modeling

Capture effect on choice of unobserved variables (attitudes, perceptions)

Integrated choice and latent variable model (Walker, 2001)
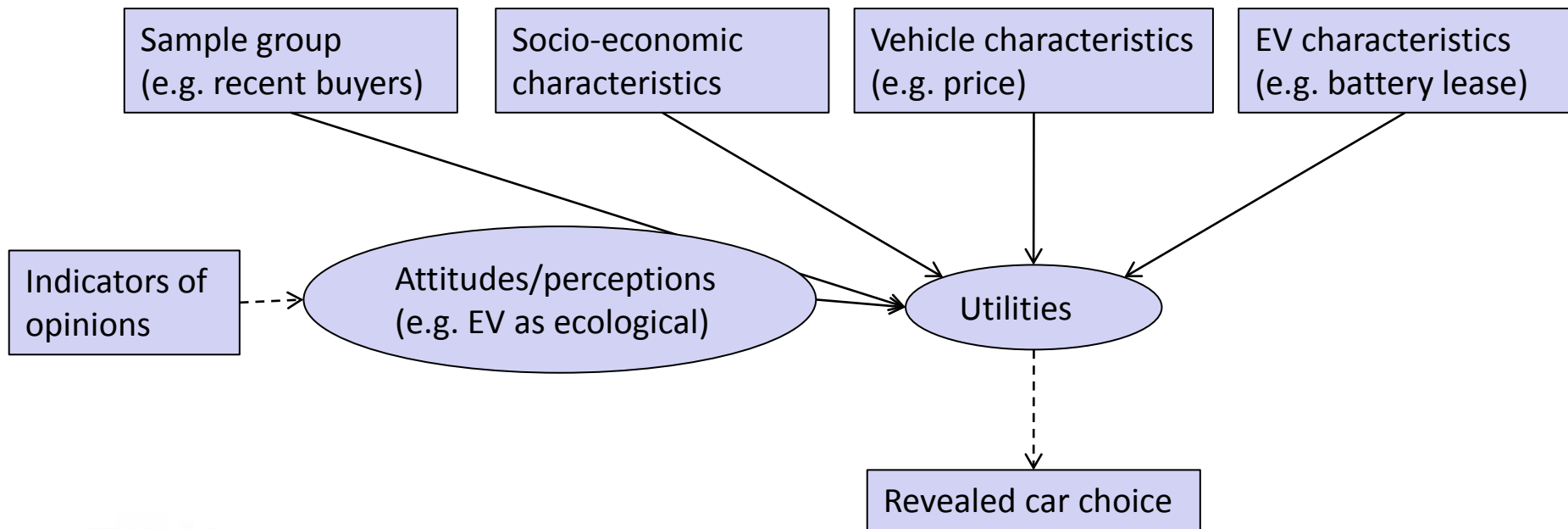
Future works: forecasting

Model estimates ➡ obtain **market shares**

Correction of market shares needed ➡ make them realistic by correcting them with market data:

- Correction of **ASC** relative to gasoline alternatives:
  - Socio-demographic characteristics (age, gender, language)
  - Sample group (recent & prospective buyers, Renault customers, pre-orders, newsletter)
- Correction for **missing alternative** 'gasoline-competitors' for owners of a Renault car
- Correction for missing alternative '**None of the cars**'

Thanks!