Modeling behavior to support economical decisions

Michel Bierlaire

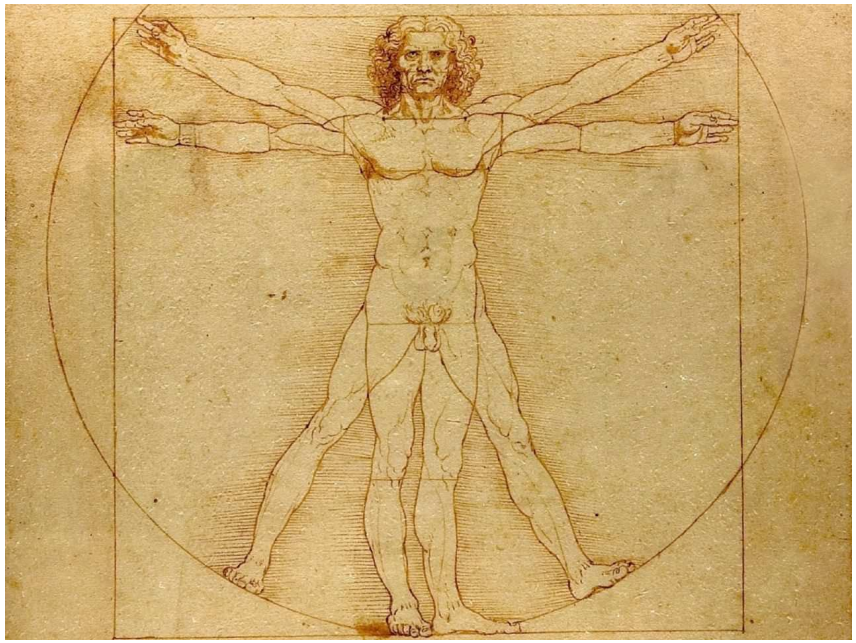
Transport and Mobility Laboratory
School of Architecture, Civil and Environmental Engineering
Ecole Polytechnique Fédérale de Lausanne

Outline

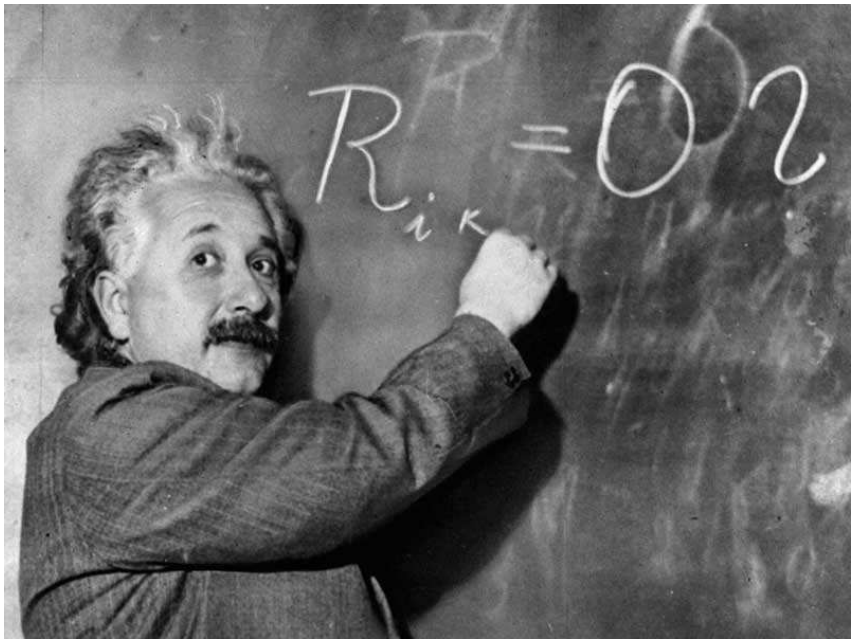
Motivation

Human dimension in

- engineering
- business
- marketing
- planning
- policy making



Motivation



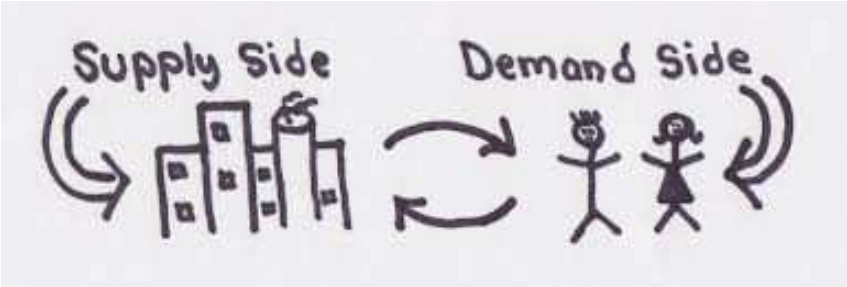
Need for

- behavioral *theories*
- quantitative *methods*
- operational mathematical *models*

Motivation

Concept of demand

- marketing
- transportation
- energy
- finance



Motivation

Concept of choice

- Marketing:brand, product
- Transport: mode, destination
- Energy: type, usage
- Finance: buy/sell, product

Applications

Willingness to pay for travel time savings

- Swiss Federal Road Office
- Compute the Swiss value of time

Applications

Market share of electrical vehicles

- Renault Suisse
- Forecasting of market shares

Applications

Dynamics of vehicle ownership

- PSA Peugeot Citroën
- Vehicle transactions model
- Changes in households vehicle ownership

Applications

Path to purchase: the case of ice creams

- Nestlé Research Center
- Impact of the design of the poster
- on the choice of ice cream

Importance

Daniel L. McFadden

- UC Berkeley 1963, MIT 1977, UC Berkeley 1991
- Laureate of *The Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel 2000*
- Owns a farm and vineyard in Napa Valley
- "Farm work clears the mind, and the vineyard is a great place to prove theorems"

Outline

Choice theory

Choice: outcome of a sequential decision-making process

- defining the choice problem
- generating alternatives
- evaluating alternatives
- making a choice,
- executing the choice.

Theory of behavior that is

- descriptive: how people behave and not how they should
- abstract: not too specific
- operational: can be used in practice for forecasting

Building the theory

Define

1. who (or what) is the decision maker,
2. what are the characteristics of the decision maker,
3. what are the alternatives available for the choice,
4. what are the attributes of the alternatives, and
5. what is the decision rule that the decision maker uses to make a choice.

Decision maker

Individual

- a person
- a group of persons (internal interactions are ignored)
  - household, family
  - firm
  - government agency
- notation: n

Characteristics of the decision maker

Disaggregate models

Individuals

- face different choice situations
- have different tastes

Characteristics

- income
- sex
- age
- level of education
- household/firm size
- etc.

Alternatives

Choice set

- Non empty finite and countable set of alternatives
- Universal: $\mathcal{C}$
- Individual specific: $\mathcal{C}_n \subseteq \mathcal{C}$
- Availability, awareness

Example

Choice of a transportation mode

- $\mathcal{C}$ ={car, bus, metro, walking }
- If the decision maker has no driver license, and the trip is 12km long

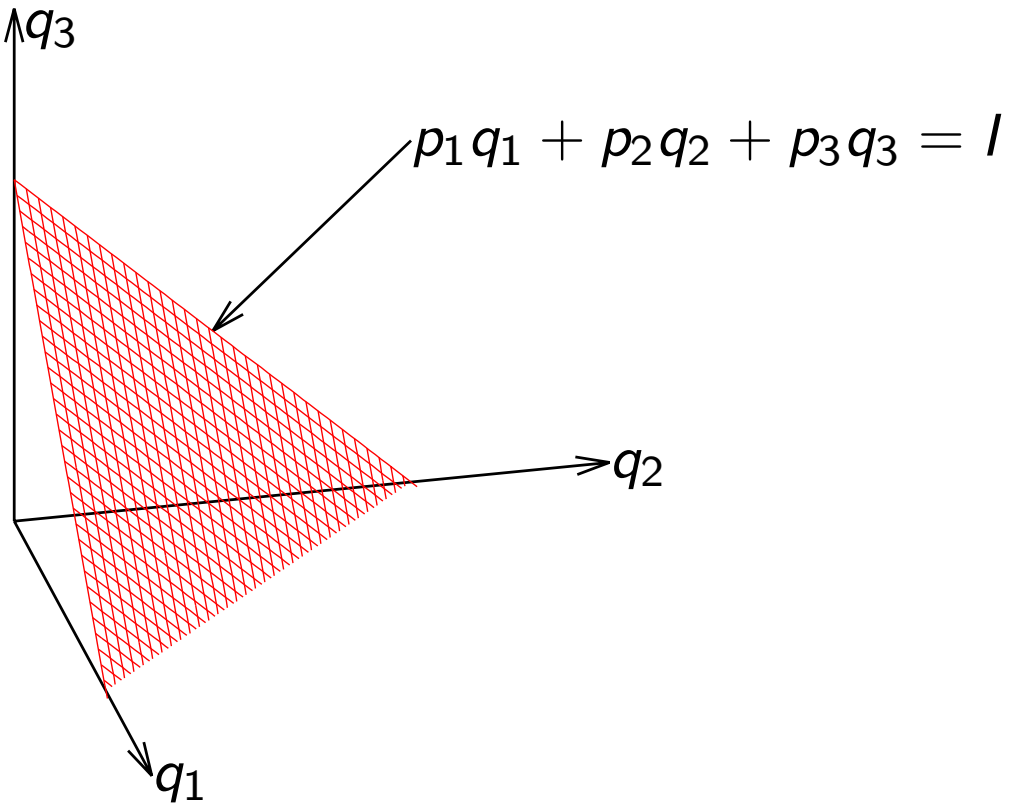
$$\mathcal{C}_n = \{\text{bus}, \text{metro}\}$$

Continuous choice set

Microeconomic demand analysis

Commodity bundle

- q_1: quantity of milk
- q_2: quantity of bread
- q_3: quantity of butter
- Unit price: p_i
- Budget: I

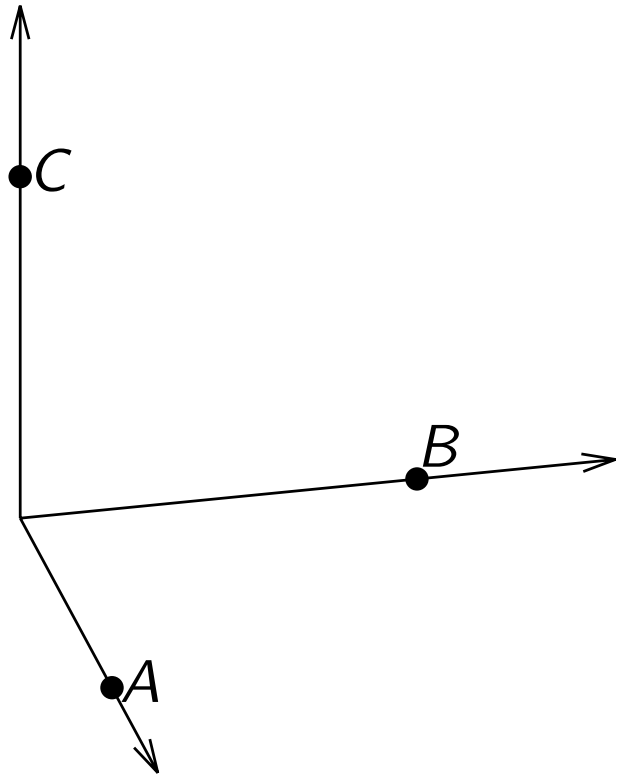


Discrete choice set

Discrete choice analysis

List of alternatives

- Brand A
- Brand B
- Brand C



Alternative attributes

Characterize each alternative i for each individual n

- price
- travel time
- frequency
- comfort
- color
- size
- etc.

Nature of the variables

- Discrete and continuous
- Generic and specific
- Measured or perceived

Decision rule

Homo economicus

Rational and narrowly self-interested economic actor who is optimizing her outcome

Utility

$$U_n : \mathcal{C}_n \longrightarrow \mathbb{R} : a \rightsquigarrow U_n(a)$$

- captures the attractiveness of an alternative
- measure that the decision maker wants to optimize

Behavioral assumption

- the decision maker associates a utility with each alternative
- the decision maker is a perfect optimizer
- the alternative with the highest utility is chosen

Simple example: mode choice

Attributes

Alternatives	Attributes	
	Travel time (t)	Travel cost (c)
Car (1)	t_1	c_1
Bus (2)	t_2	c_2

Simple example: mode choice

Utility functions

$$\begin{aligned} U_1 &= -\beta_t t_1 - \beta_c c_1, \\ U_2 &= -\beta_t t_2 - \beta_c c_2, \end{aligned}$$

where $\beta_t > 0$ and $\beta_c > 0$ are parameters.

Equivalent specification

$$\begin{aligned} U_1 &= -(\beta_t/\beta_c) t_1 - c_1 &= -\beta t_1 - c_1 \\ U_2 &= -(\beta_t/\beta_c) t_2 - c_2 &= -\beta t_2 - c_2 \end{aligned}$$

where $\beta > 0$ is a parameter.

Choice

- Alternative 1 is chosen if $U_1 \geq U_2$.
- Ties are ignored.

Simple example: mode choice

Choice

Alternative 1 is chosen if

$$-\beta t_1 - c_1 \geq -\beta t_2 - c_2$$

or

$$-\beta(t_1 - t_2) \geq c_1 - c_2$$

Alternative 2 is chosen if

$$-\beta t_1 - c_1 \leq -\beta t_2 - c_2$$

or

$$-\beta(t_1 - t_2) \leq c_1 - c_2$$

Dominated alternative

- If $c_2 > c_1$ and $t_2 > t_1$, $U_1 > U_2$ for any $\beta > 0$
- If $c_1 > c_2$ and $t_1 > t_2$, $U_2 > U_1$ for any $\beta > 0$

Simple example: mode choice

Trade-off

- Assume $c_2 > c_1$ and $t_1 > t_2$.
- Is the traveler willing to pay the extra cost $c_2 - c_1$ to save the extra time $t_1 - t_2$?
- Alternative 2 is chosen if

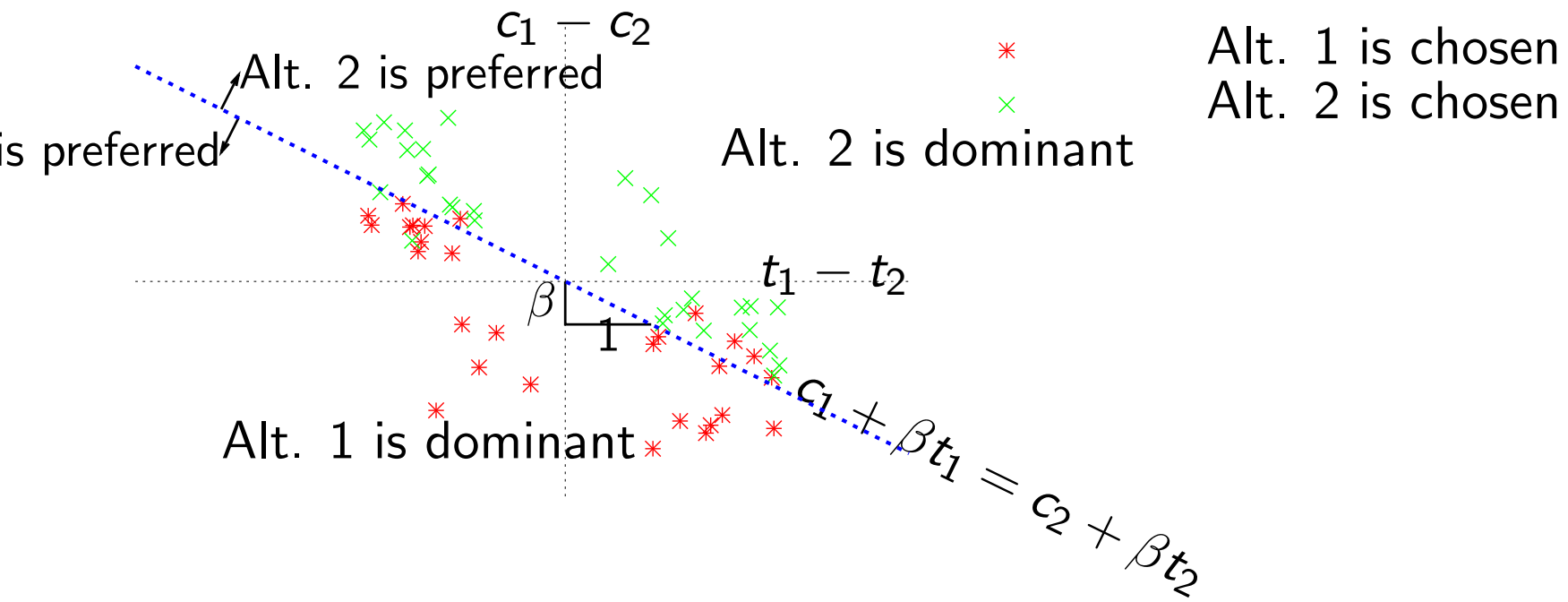
$$-\beta(t_1 - t_2) \leq c_1 - c_2$$

or

$$\beta \geq \frac{c_2 - c_1}{t_1 - t_2}$$

- β is called the *willingness to pay* or *value of time*

Simple example: mode choice



Random utility model

Random utility

$$U_{in} = V_{in} + \varepsilon_{in}.$$

The logit model

$$P(i|\mathcal{C}_n) = \frac{e^{V_{in}}}{\sum_{j \in \mathcal{C}_n} e^{V_{jn}}}$$

Outline

Choice data

Revealed preferences

- actual choice observed
- in real market situations
- Example: scanner data in supermarkets

Stated preferences

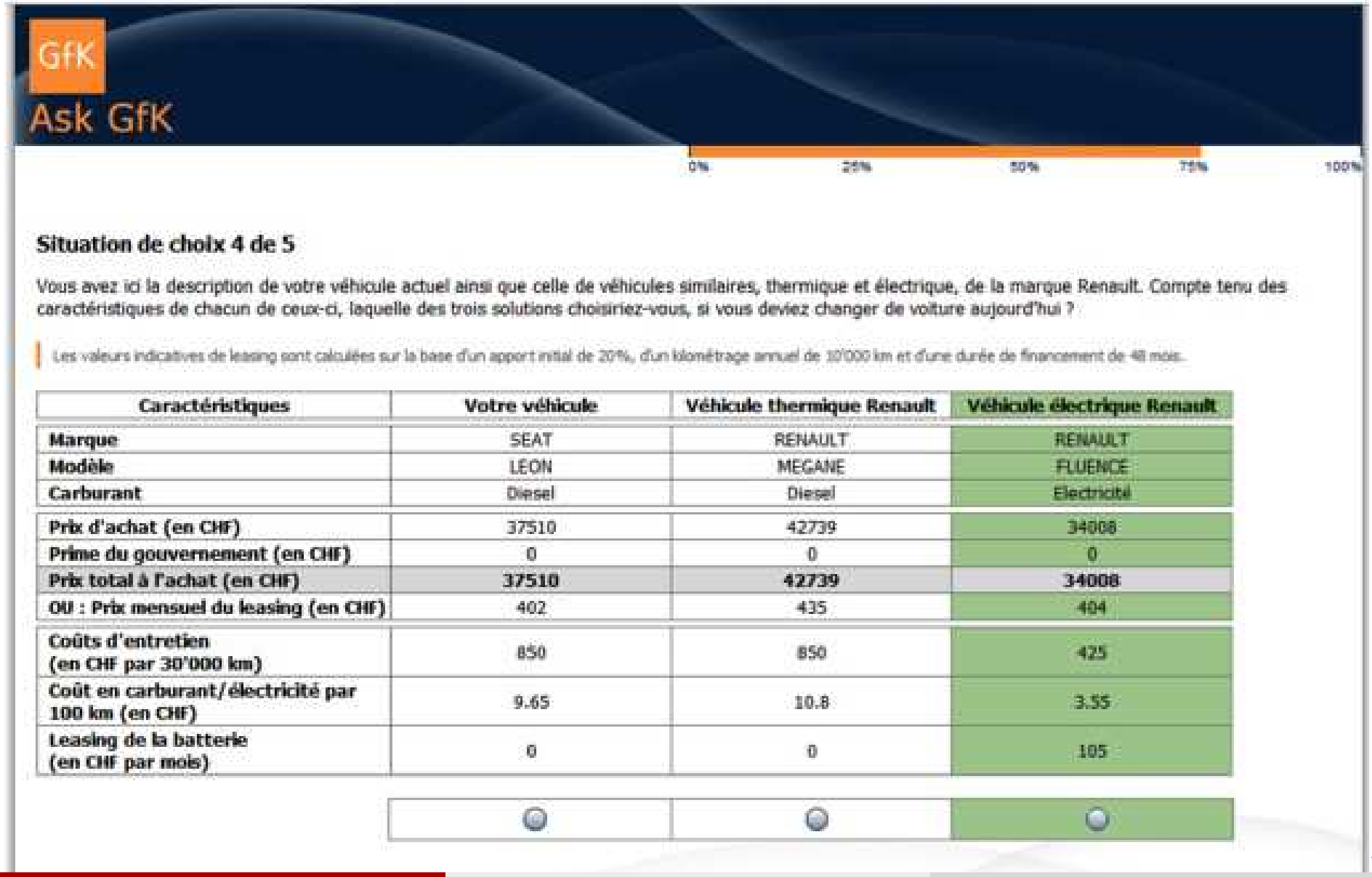
- hypothetical situations
- attributes defined by the analyst

Data

Questionnaires

- Data about the respondent
- Choice data
- Revealed preferences
- Stated preferences

Data: example of a questionaire



GfK

Ask GfK

0% 25% 50% 75% 100%

Situation de choix 4 de 5

Vous avez ici la description de votre véhicule actuel ainsi que celle de véhicules similaires, thermique et électrique, de la marque Renault. Compte tenu des caractéristiques de chacun de ceux-ci, laquelle des trois solutions choisiriez-vous, si vous deviez changer de voiture aujourd'hui ?

Les valeurs indicatives de leasing sont calculées sur la base d'un apport initial de 20%, d'un kilométrage annuel de 10'000 km et d'une durée de financement de 48 mois.

Caractéristiques	Votre véhicule	Véhicule thermique Renault	Véhicule électrique Renault
Marque	SEAT	RENAULT	RENAULT
Modèle	LEON	MEGANE	FLUENCE
Carburant	Diesel	Diesel	Electricité
Prix d'achat (en CHF)	37510	42739	34008
Prime du gouvernement (en CHF)	0	0	0
Prix total à l'achat (en CHF)	37510	42739	34008
OU : Prix mensuel du leasing (en CHF)	402	435	404
Coûts d'entretien (en CHF par 30'000 km)	850	850	425
Coût en carburant/électricité par 100 km (en CHF)	9.65	10.8	3.55
Leasing de la batterie (en CHF par mois)	0	0	105

Data

Smartphones

- GSM, GPS
- Accelerometer
- WiFi
- Bluetooth
- Ambient sound
- And more...

Data

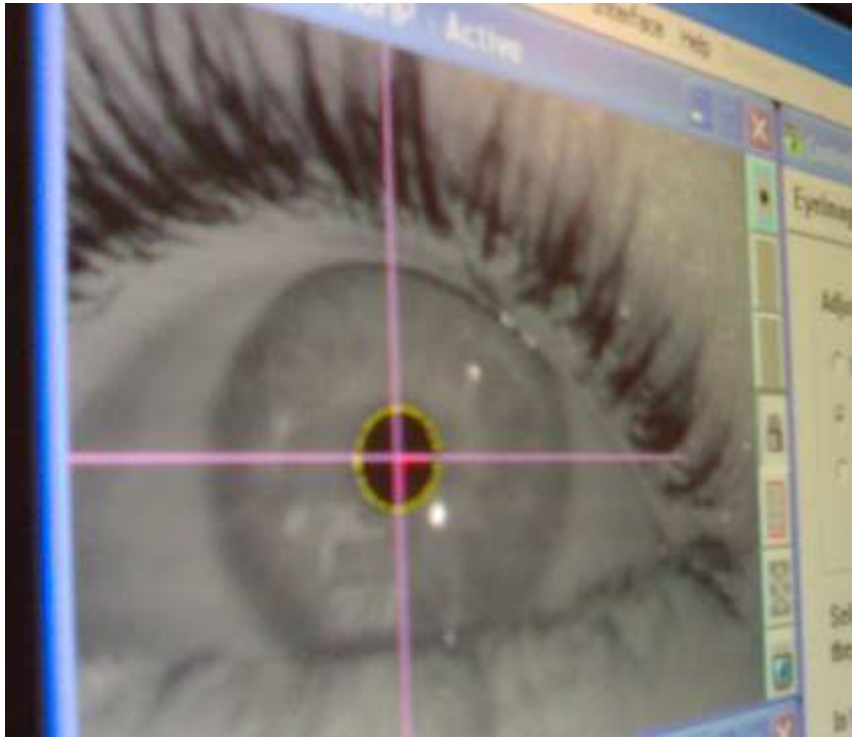
Scanner data

- Detailed purchase information
- Personalized

Data

Eye tracking

- Where do people look?
- Used in marketing research
- Used in driving safety research
- Relevant for pedestrian models



Data: eye tracking

Movie: Nestlé data collection

Outline

Market shares of electrical vehicles

Glerum, A., Stankovikj, L., Thmans, M., and Bierlaire, M. (to appear)

Forecasting the demand for electric vehicles: accounting for attitudes and perceptions, *Transportation Science* (accepted for publication on May 29, 2013)

Objectives

Demand analysis for two electrical vehicles: Zoe & Fluence (Renault)

Sample

Target groups

Sampling from

- Recent buyers
- Prospective buyers
- Renault customers

Everybody from

- Pre-orders
- Z. E. newsletter

Sampling protocol: representative for

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

Sample

High response rate - possibility to segment

Group name	Sent	Phase I		Phase II		Phase I vs phase II
		Number	Rate	Number	Rate	Rate
Recent buyers	3006	150	10.0%	141	9.4%	94.0%
Prospective buyers		151		141		93.4%
Renault customers	1000	145	14.5%	120	12.0%	82.8%
Pre-orders	42	23	54.8%	19	45.2%	82.6%
Z.E. newsletter	656	197	30.0%	172	26.2%	87.3%
Total	4704	666	14.2%	593	12.6%	89.0%

Sample

Unbalanced sample (gender): need for corrections

Variable	Level	Targeted rate	Rate phase I	Rate phase II
Language	German	72.5%	67.3%	67.8%
	French	23.0%	27.2%	26.6%
	Italian	4.5%	5.6%	5.6%
Gender	Male	49.4%	74.0%	74.2%
	Female	50.6%	26.0%	25.8%
Age category	18-35 years	33.6%	23.0%	21.8%
	36-55 years	41.6%	51.8%	52.6%
	56-74 years	24.8%	25.2%	25.6%

Survey

Phase I

- Characteristics of car(s) of respondents household
- Socio-economic information
- Mobility habits

Phase II

- Opinions and perceptions on topics related to EV
- Choice situations
- Willingness-to-pay
- Interest in additional services

Design of the choice experiment

EV variable		Level 1	Level 2	Level 3	Level 4
Purchase price	< 55 KCHF	($P_{gasoline}$ + 5'000) * 0.8	($P_{gasoline}$ + 5'000) * 1	($P_{gasoline}$ + 5'000) * 1.2	-
	≥ 55 KCHF	($P_{Mégane}$ + 5'000) * 0.8	($P_{Mégane}$ + 5'000) * 1	($P_{Mégane}$ + 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	-

Segmentation

A priori higher interest for EV and/or Renault

- Pre-orders (1)
- Subscribers of the Z.E. newsletter (2)

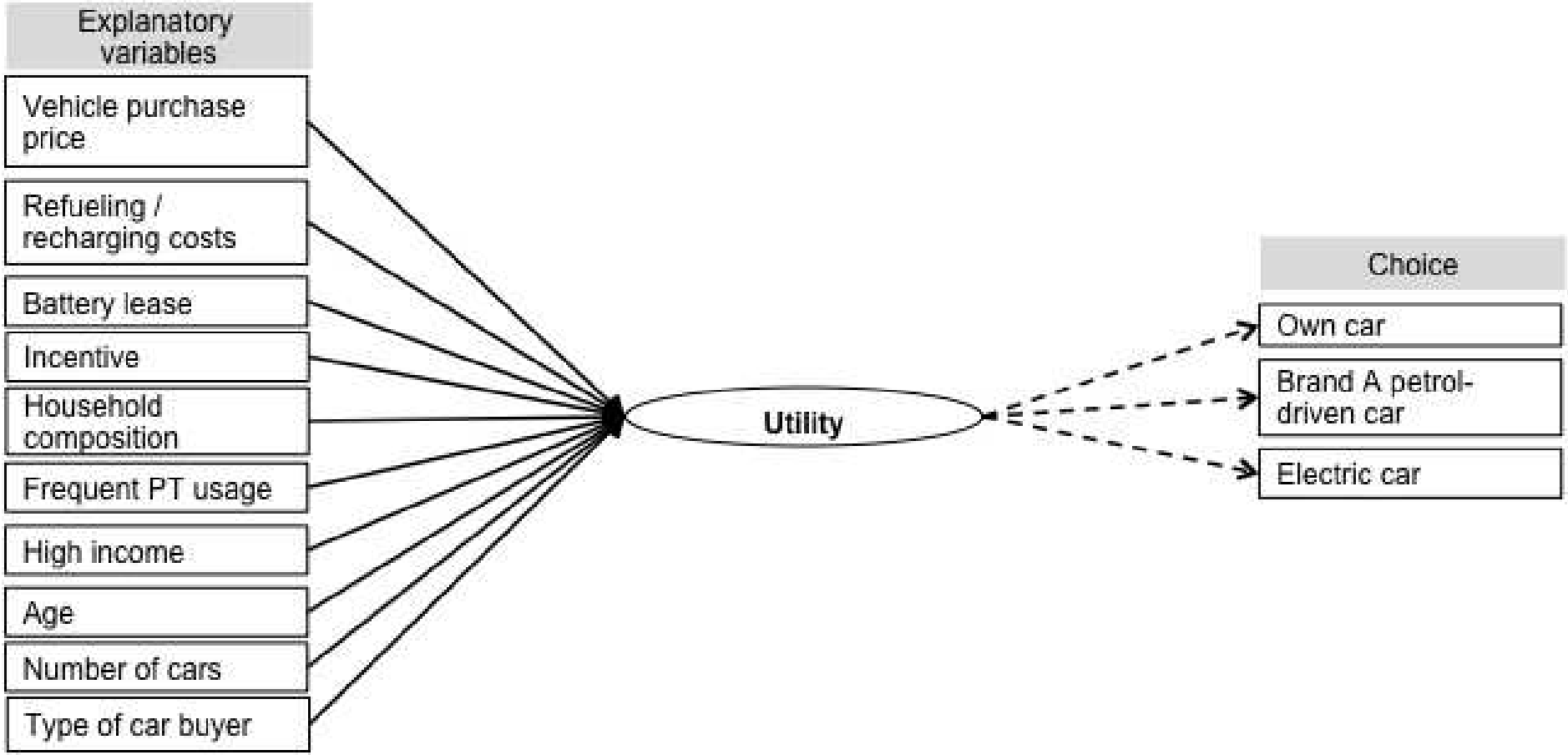
A priori interest in Renault

- Renault customers (3)

No a priori interest for EV and/or Renault

- Recent buyers (4)
- Prospective buyers (5)

Model specification



Parameter estimates

Utilities	Competitor – Gasoline (CG)	Renault – Gasoline (RG)	Renault – Electric (RE)
-0.0212**	Prix CG	-	-
-0.211	-	Price RG · TG1245	-
-0.598	-	Price RG · TG3	-
-0.404	-	-	Price RE · TG12
-1.00	-	-	Price RE · TG3
-0.628	-	-	Price RE · TG45
-0.049**	Operating cost gasoline	Operating cost gasoline	-

Utilities	Competitor – Gasoline (CG)	Renault – Gasoline (RG)	Renault – Electric (RE)
-0.252	-	-	High operating cost · Fluence
-0.778	-	-	High operating cost · Zoé
-0.447	-	-	Medium operating cost · Zoé
-0.205*	-	-	High battery lease
-0.0539**	-	-	Medium battery lease
0.73	-	-	High incentive
0.0803**	-	-	Medium incentive
-0.00224**	-	-	Low incentive

Parameter estimates

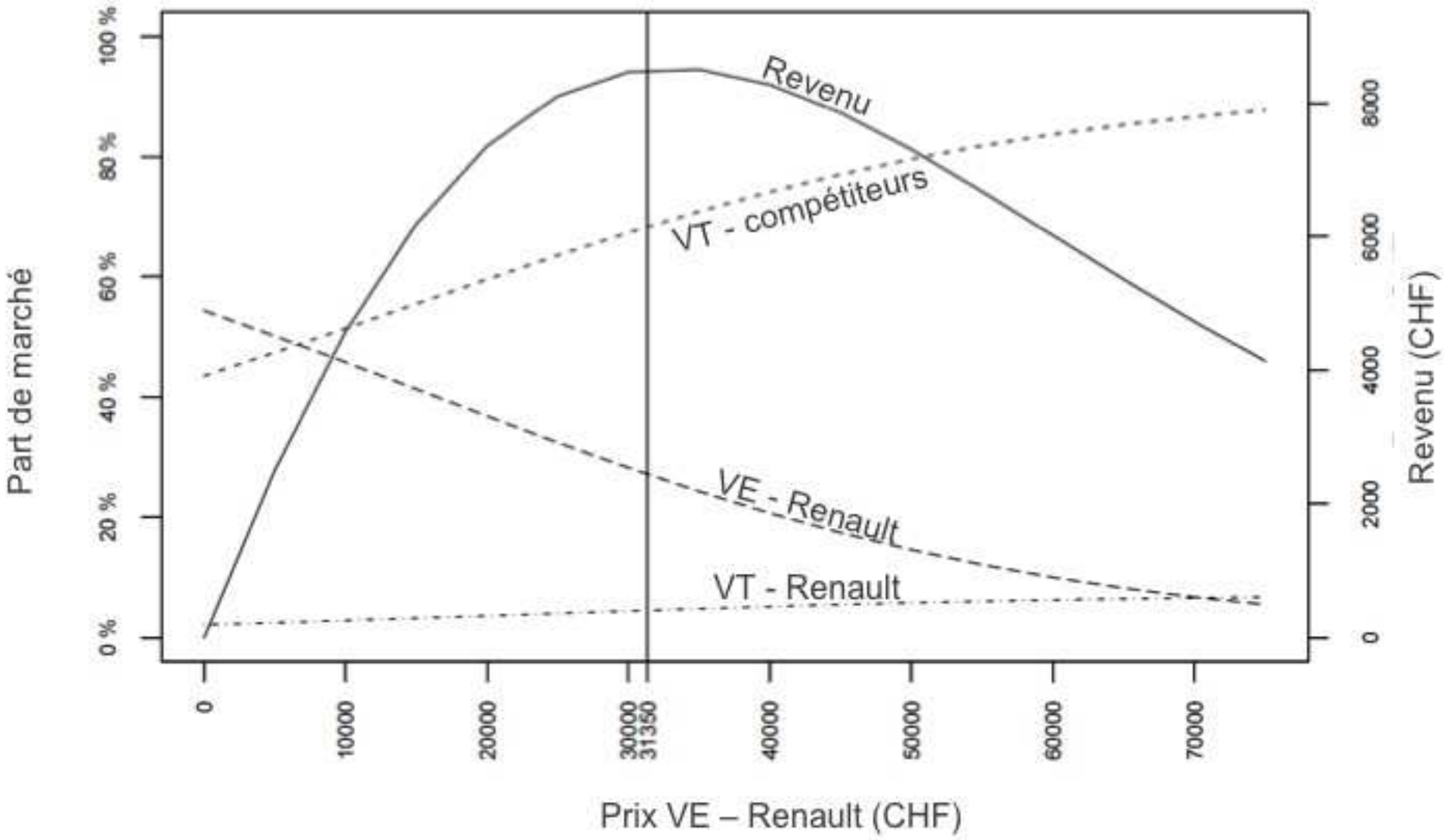
Utilities	Competitor – Gasoline (CG)	Renault – Gasoline (RG)	Renault – Electric (RE)
-0.279	PT · TG1245	-	-
-0.552	-	PT · TG1245	-
-1.85	PT · TG3	-	-
-1.07	-	PT · TG3	-
-0.217	Family with children	-	-
0.0454**	-	Family with children	-
-0.25	Income	-	-
-0.297	-	Income	-

Utilities	Competitor – Gasoline (CG)	Renault – Gasoline (RG)	Renault – Electric (RE)
-0.172	Nb cars · TG1245	-	-
-0.157	-	Nb cars · TG1245	-
-0.384**	Nb cars · TG3	-	-
-0.729	-	Nb cars · TG3	-
0.335	French	-	-
0.0876**	-	French	-
0.0124	Age	-	-
-0.00187**	-	Age	-

Parameter estimates

Utilities	Competitor – Gasoline (CG)	Renault – Gasoline (RG)	Renault – Electric (RE)
1.97	TG12	-	-
1.04	-	TG12	-
-0.635	TG3	-	-
2.45	-	TG3	-
-2.12	1	-	-
-1.67	-	1	-

Market shares and revenues



Outline

Value of time in Switzerland

Axhausen, K., Hess, S., Koenig, A., Abay, G., Bates, J., and Bierlaire, M. (2008)

Income and distance elasticities of values of travel time savings: new Swiss results, *Transport Policy* **15**(3):173-185.

Data collection

- Source for recruitment: survey "Kontinuierliche Erhebung zum Personenverkehr" (KEP) by SBB/CFF
- Stated preferences
- Questionnaire designed based on a real reference trip
- Three parts:
  - SP mode choice (car / bus or rail)
  - SP route choice (current mode or alternative mode)
  - Socio-demographics and information about the reference trip

Value of time in Switzerland

Mode choice car – rail (main study version)

Travel costs:	18 Fr.
Total travel time:	40 minutes
... congested:	10 minutes
... uncongested:	30 minutes

Travel costs:	23 Fr.
Travel time:	30 minutes
Headway:	30 minutes
No. of changes:	0 times

☐ ← Your choice → ☐

Route choice rail (main study version)

Travel costs:	20 Fr.
Travel time:	40 minutes
Headway:	15 minutes
No. of changes:	1 times

Travel costs:	23 Fr.
Travel time:	30 minutes
Headway:	30 minutes
No. of changes:	0 times

Value of time in Switzerland

Number of observations (1225 individuals)

	Business	Commuters	Leisure	Shopping	Total
Mode : car/bus	6	162	186	126	480
Mode : car/rail	426	1716	2538	1104	5784
Route : bus for bus users	9	405	450	342	1206
Route : car for car users	156	846	1176	660	2838
Route : rail for car users	126	594	837	504	2061
Route : rail for rail users	324	1008	1881	288	3501
Total	1047	4731	7068	3024	15870

Value of time in Switzerland

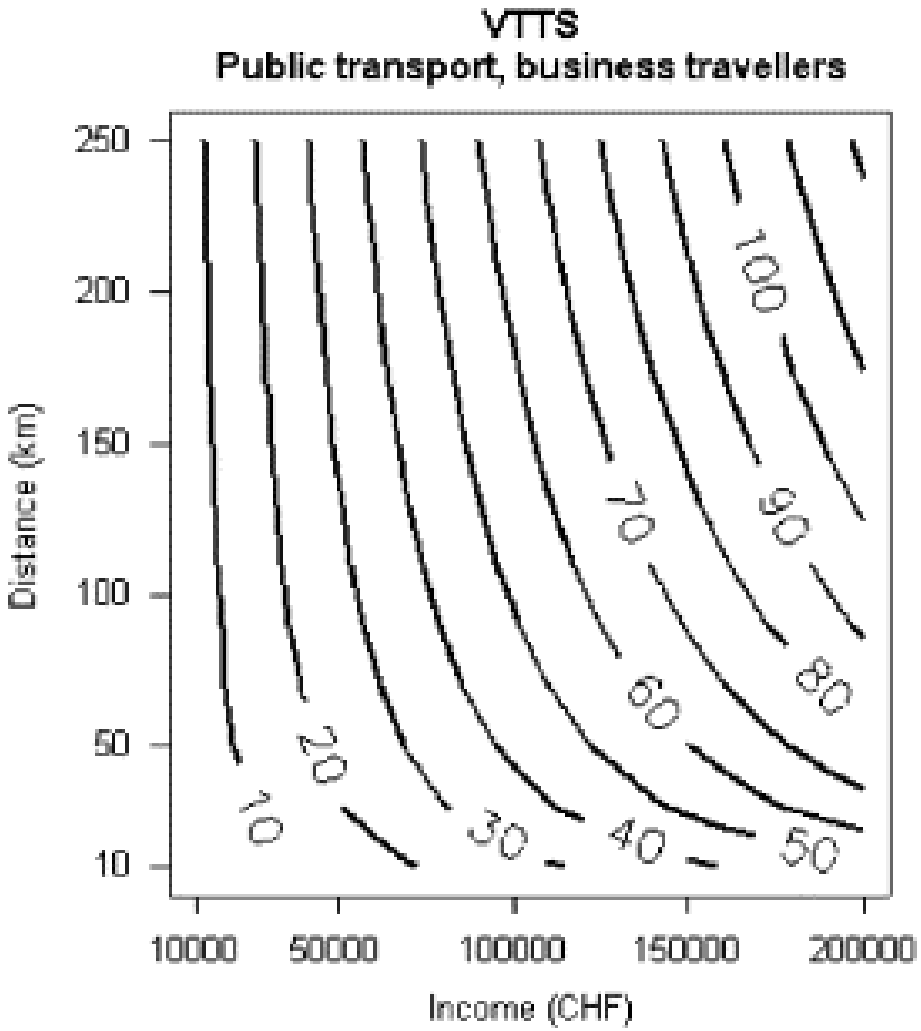
Explanatory variables

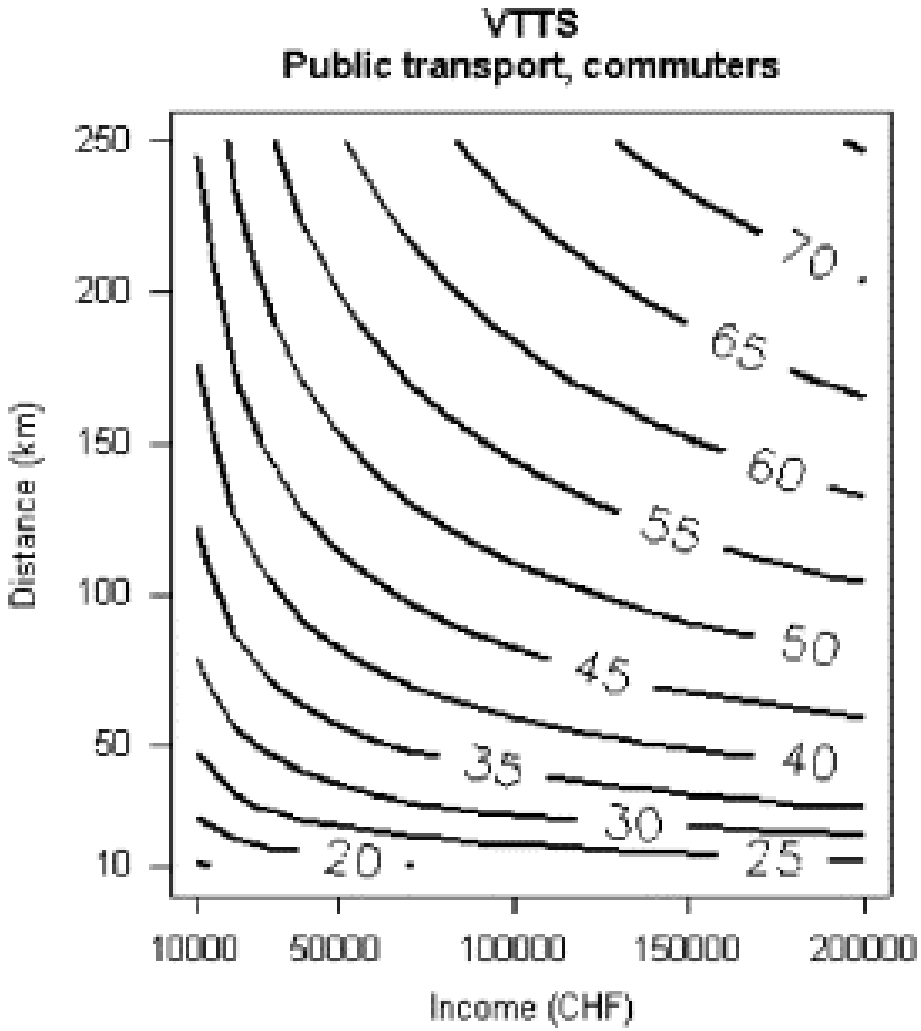
- travel time
- travel cost
- level of congestion (car)
- frequency (TC)
- number of transfers (TC)
- trip length
- income
- inertia
- car availability
- sex
- 1/2-fare CFF
- general subscription
- trip purpose

Value of time in Switzerland

	Business	Commute	Leisure	Shopping
Time TC (CHF/h)	49.57	27.81	21.84	17.73
Time car (CHF/h)	50.23	30.64	29.20	24.32
Headway (CHF/h)	14.88	11.18	13.38	8.48
CHF/transfer	7.85	4.89	7.32	3.52

Value of time in Switzerland





Value of time in Switzerland

Value of time varies (namely) with

- transportation mode,
- trip purpose,
- income,
- trip length.

Outline

Reference

Stathopoulos, A., Glerum, A., Thmans, M., and Bierlaire, M. (2013)

Dynamic vehicle ownership forecasting: a framework to model inter-temporal renewal decisions. Proceedings of the Swiss Transportation Research Conference (STRC) 24-26 April, 2013.

Objectives

Vehicle transactions model capturing changes in a household's vehicle ownership status

- Account for the behavioral principles that govern renewal behavior
- **changes in ownership** (car market transactions) are explained
- Two goals:
  1. quantify impact of different **time-varying factors** that drive vehicle replacement over time.
  2. delineate a detailed vehicle **transition-matrix**

Available data

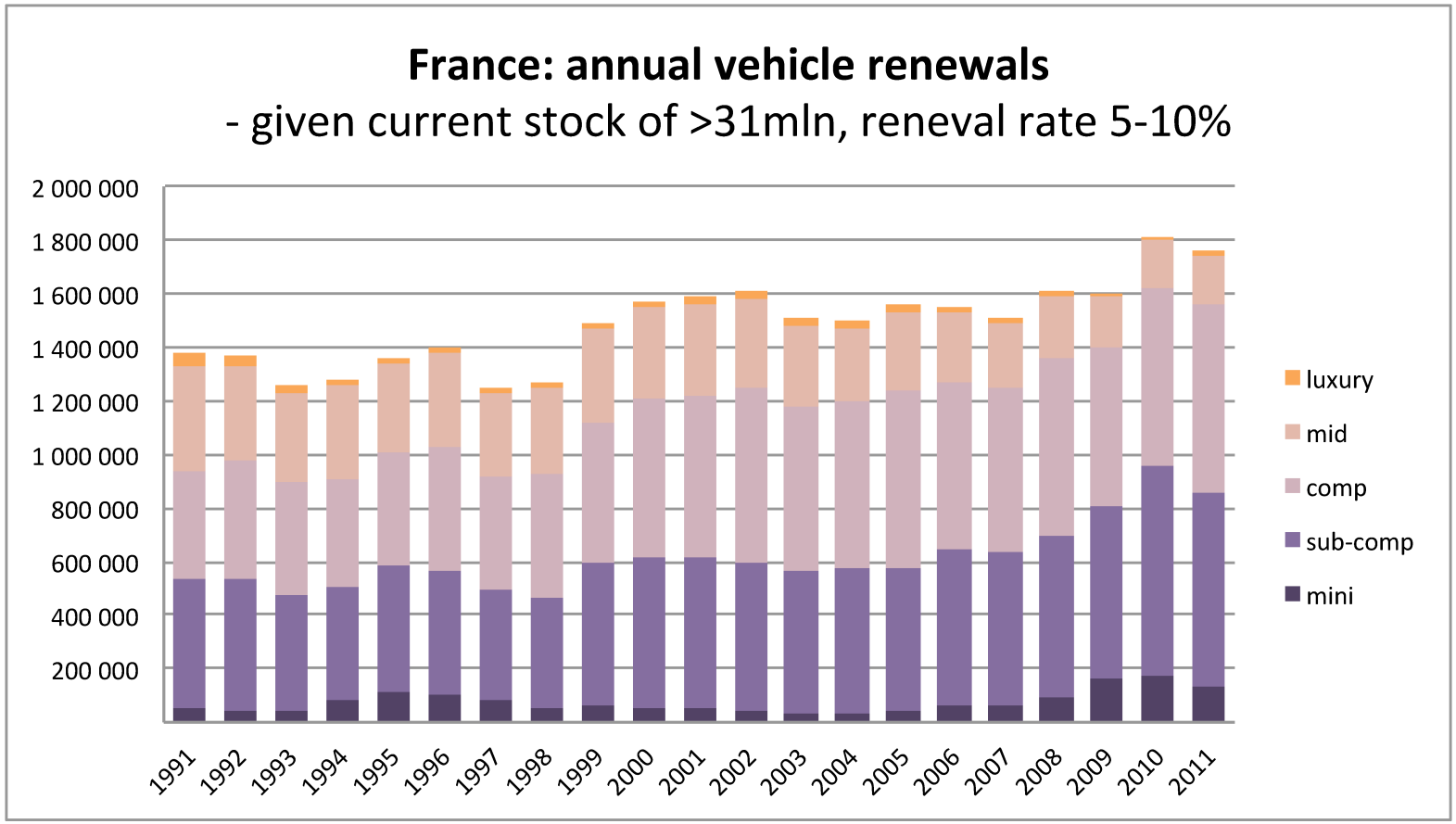
Revealed choices: New car acquisitions

Working with *undisclosed survey company* we have access to repeated cross-section over 20 years (1991-2011):

- representative sample of **all** car-buyers in major EU markets
- detailed survey on new + past vehicle
- sociodemographics for buyer and household
- 'soft' indicators such as motivations, attitudes

Dimension of data is approximately 30'000 rows / year = car acquisitions. These are weighed to represent annual new car registrations (c.a. 1.5 million)

Applied to the french market



E.g. for 2011 we have 39'000 data-rows, reweighed to represent the 1'700'000 vehicle acquisitions (>90% renewers)

Method

Markov Chain with m states

- A state = a car segment
- Transition matrix, T specifies the probabilities that the system moves from one state to another in a unit of time.
- T-matrix is unknown with no restrictions, but estimated from the data.
- Parameters to infer are m^2 matrix entries p_{ij} defined as

$$p_{ij} = Pr(X_{t+1} = j | X_t)$$

- We observe from the sample the chain of realizations of the different shifts across car segments (6 origins, 5 destinations = 30 entries in T)

Model structure

Macroscopic events

- current vehicle features
- political interventions
- vehicle market-dynamics
- economic variables
- past choice
- used market...

- **explain** transaction behavior over 20 years
- In particular, timing of transition
- Enable forecasting based on making assumptions on the variables

Model structure

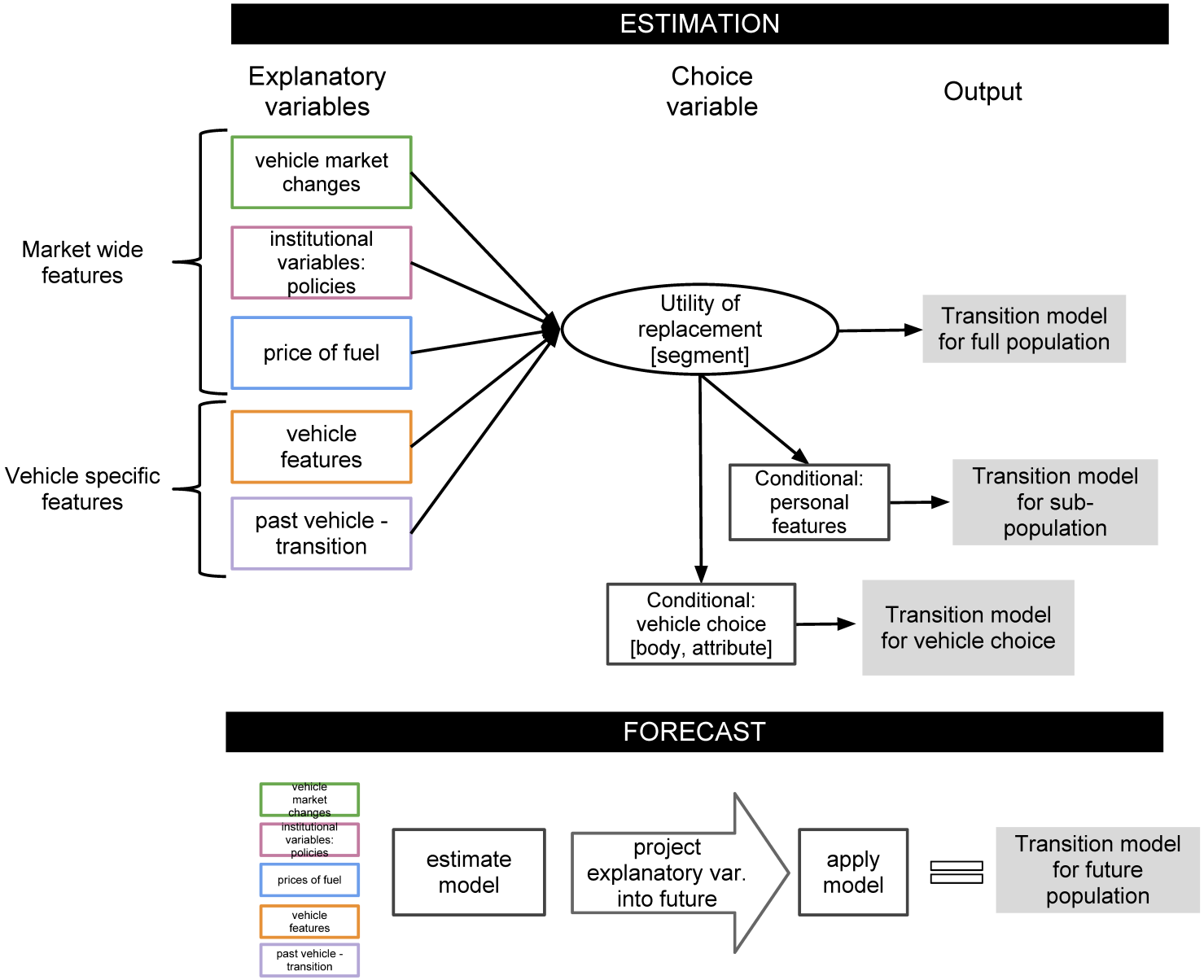
Discrete choice

- Aggregate data $\rightarrow$ assumes W identical households choosing a vehicle segment.
- In application the modeled choices are weighted by W.

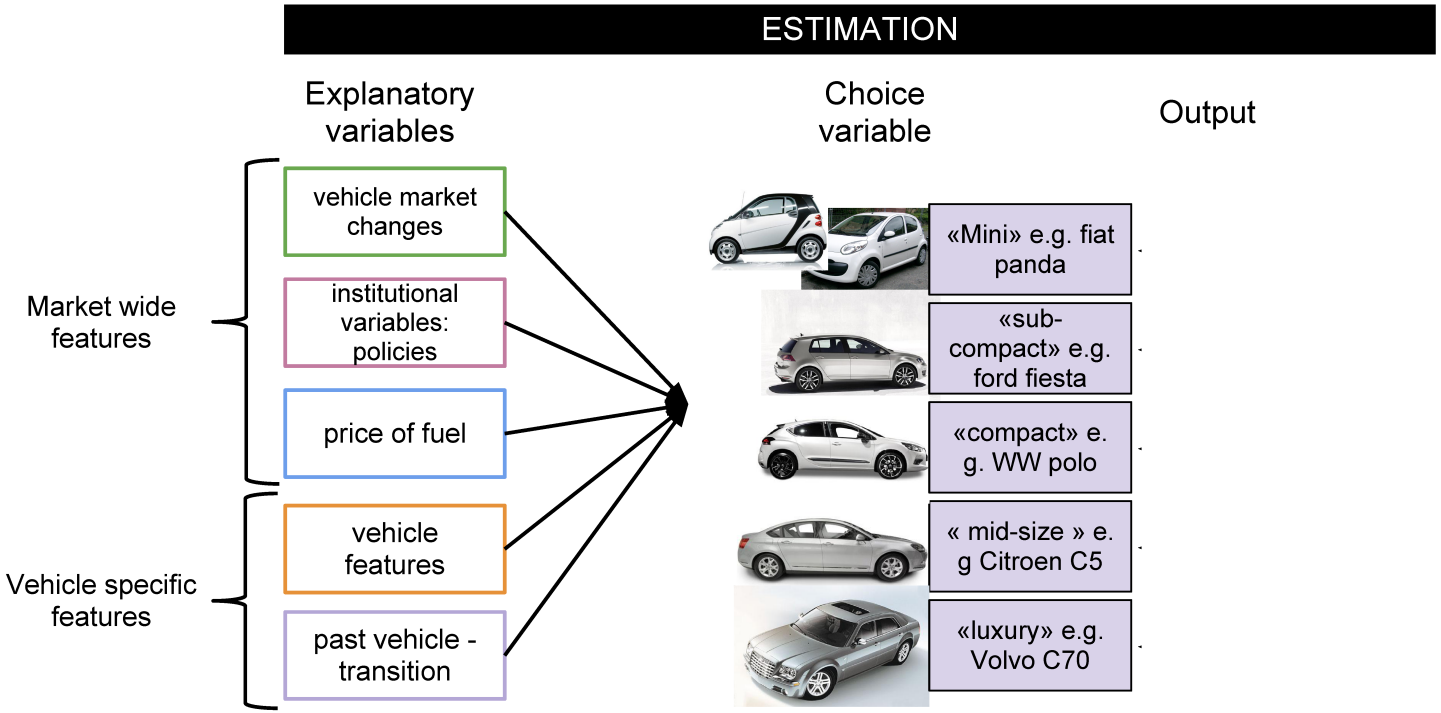
Utility specification

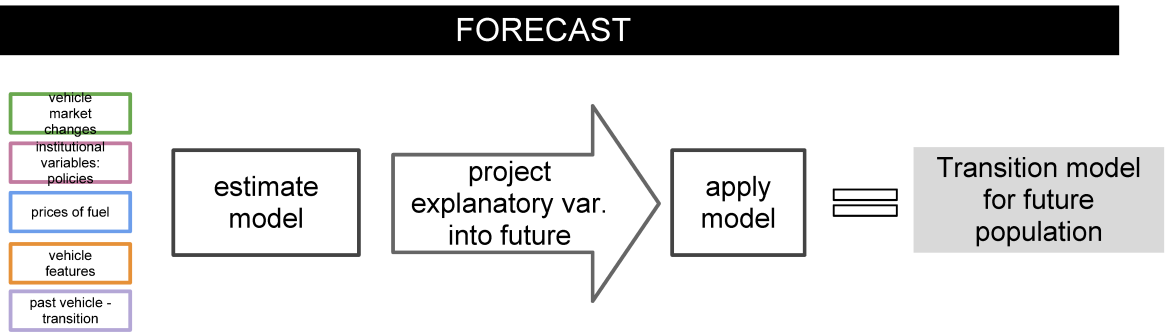
$$
\begin{aligned}
V^{w}_{\mathrm{j,t}} \quad & = f(\beta_{ASC}\mathrm{SEGMENT}_j \\
& + \beta\mathrm{TRANSITIONS}\{\mathrm{PREV\_TO\_NEW\_SEGMENT}\}_{j,t} \\
& + \beta\mathrm{NEWVEHICLE}\{\mathrm{PRICE}, \mathrm{CONSO}\}_{j,t} \\
& + \beta\mathrm{POLICIES}\{\mathrm{BONMAL}, \mathrm{CO2}, \mathrm{SCRAP}\}_{t} \\
& + \beta\mathrm{VEHICLESUPPLY}\{\mathrm{nbALTFUEL}, \mathrm{nbCITY}, \mathrm{nbMONO}, \mathrm{nbSUV}, \mathrm{nbUSED}\}_{t} \\
& + \beta\mathrm{MARKET}\{\mathrm{PETROL}\}_{t})
\end{aligned}
$$

Model structure



Model structure





Results

parameter	Beta	t-test
ASC__Min	0.71	1.2
ASC__Sub	2.02	8.6
ASC_Comp	0.36	1.4
ASC_Mid	1.47	6.2
β_T_Min_to_Min	4.45	8.6
β_T_Min_to_Sub	3.52	6.8
β_T_Min_to_Comp	2.71	5.2
β_T_Min_to_Mid	1.23	2.3
β_T_Sub_to_Min	2.52	11.1
β_T_Sub_to_Sub_	3.23	14.5
β_T_Sub_to_Comp	2.62	11.7
β_T_Sub_to_Mid	1.36	5.9
β_T_Lux_to_Min	-4.46	-23.8
β_T_Lux_to_Sub	-4.08	-34.6
β_T_Lux_to_Comp	-2.91	-26.5
β_T_Lux_to_Mid	-1.61	-15.0
β_T_Comp_to_Min	0.09	0.6
β_T_Comp_to_Sub	1.05	7.4
β_T_Comp_to_Comp	2.39	16.7
β_T_Comp_to_Mid	1.55	10.5
β_T_Mid_to_Min	-2.16	-16.3
β_T_Mid_to_Sub	-1.53	-14.5
β_T_Mid_to_Comp	-0.07	-0.6
β_T_Mid_to_Mid	1.01	9.3

First 4 param. are the **constants** (intrinsic utility) for the vehicle type with luxury = baseline

Remaining coefficients are the '**transition coefficients**': observe that highest value is always for staying in the the same segment (e.g. BETA_Min_to_Min)

Results: veh. market & veh. features

parameter	Beta	t-test
β_NBALTFUEL_Sub	0.14	1.5
β_NBALTFUEL_Comp	0.20	2.3
β_NBCITY_Min	0.20	2.3
β_NBCITY_Sub	0.13	3.0
β_NBMONO_Min	-1.92	-3.0
β_NBSUV_Comp	0.11	1.3
β_NBUSED_COMP_Comp	-0.09	-1.9
β_NBUSED_TOT_Mid	-0.01	-0.9
β_PRICE_Min	-0.15	-2.0
β_PRICE_Sub	-0.13	-3.6
β_PRICE_Comp	-0.02	-0.7
β_PRICE_Mid	-0.09	-4.2
β_PRICE_Lux	-0.04	-3.8
β_CONS_Min	-0.03	-1.7
β_CONS_Lux	-0.02	-1.7

Alternative fuel vehicles favor smaller ranges

Sub-Compact buyers react more positively to increasing offer of Nb city cars

Mini class buyers most price sensitive

Fuel consumption sensitivity higher in extreme classes

Results: fuel & policies

Parameter	Beta	t-test
β_PETROL_Sub	-0.20	-6.0
β_PETROL_Comp	-0.18	-5.1
β_PETROL_Mid	-0.14	-3.7
β_PETROL_Lux	-0.33	-7.0
β_BONMAL_Min	1.12	8.0
β_BONMAL_Sub	0.29	3.0
β_CO2_Comp	-0.21	-3.7
β_CO2_Mid	-0.20	-2.8
β_SCRAP_Min	0.19	2.5
β_SCRAP_Sub_Mid	0.07	2.0

Price premium for fuel (petrol over diesel) has most impact on Luxury and Sub-compact

Bonus-Malus has positive impact on buying Mini and Sub-Compact

Surtaxe CO_2 negative impact on buying Compact and Mid-Size

Model summary

Number of estimated parameters:	49
Sample size:	756 rows = 6 alternatives
Init log-likelihood:	-64663.406
Final log-likelihood:	-43969.919
ρ^2 **adj.:**	0.319

Example transition matrix (2011)

2011

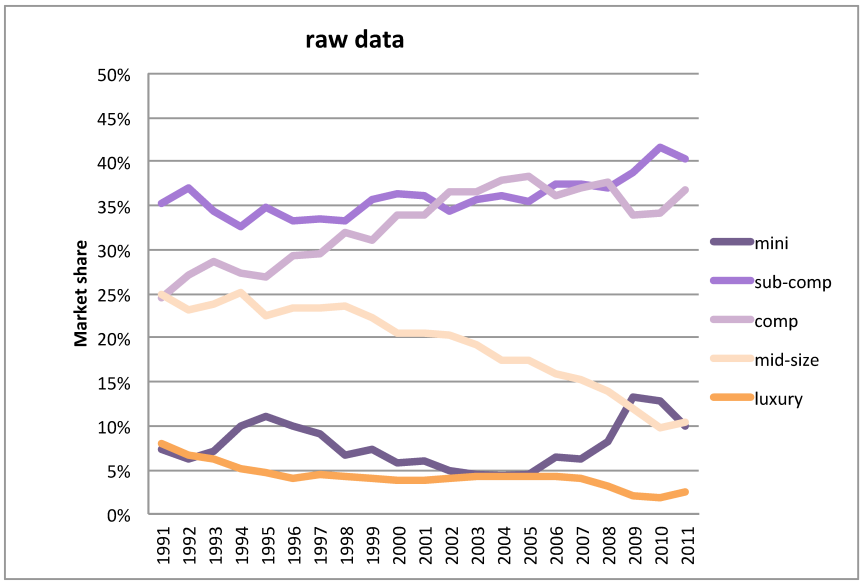
Origin (row) / destination (col)	mini	sub-comp	comp	mid-size	luxury
mini	0.486	0.429	0.080	0.004	0.000
sub-comp	0.135	0.674	0.178	0.012	0.001
comp	0.041	0.293	0.585	0.072	0.005
mid-size	0.028	0.188	0.423	0.328	0.033
luxury	0.024	0.122	0.228	0.242	0.385
no car	0.163	0.402	0.313	0.089	0.033

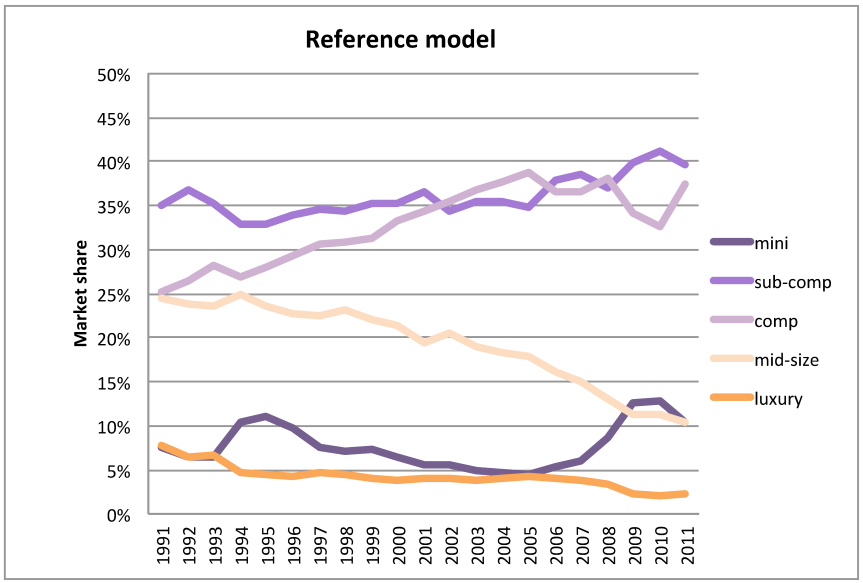
From the model coefficients we obtain the transition matrix with 30 entries = 6rows*5col (because we know entries of new buyers but not exits)

We can observe what buyers from different origins do: e.g. Sub-Comp is the group more faithful to Sub-Comp (67%) and are a bit more likely to up-range (to Comp) than down-range (to Mini)

Validation of the model

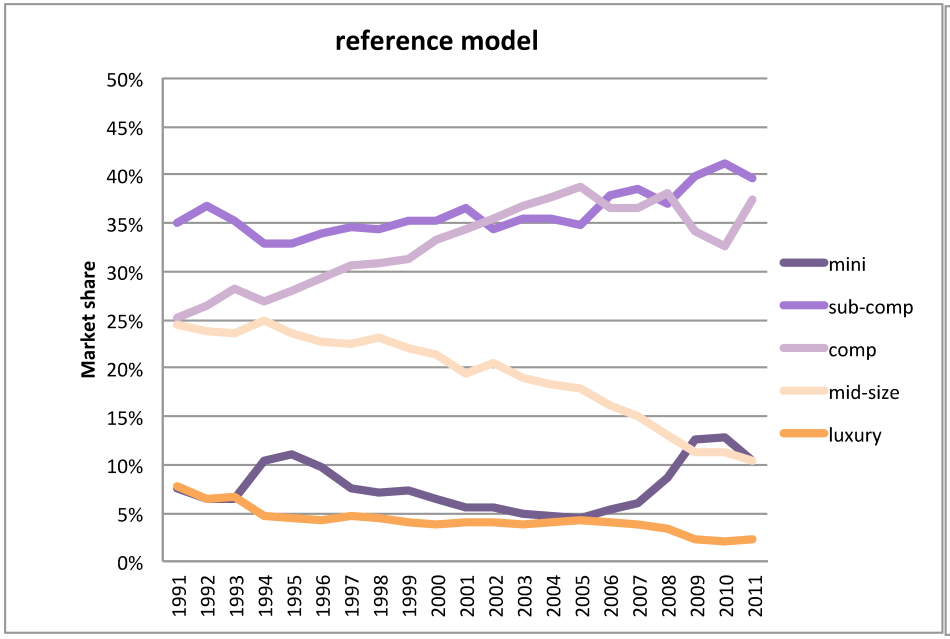
The ultimate validation is against the real observed market-shares

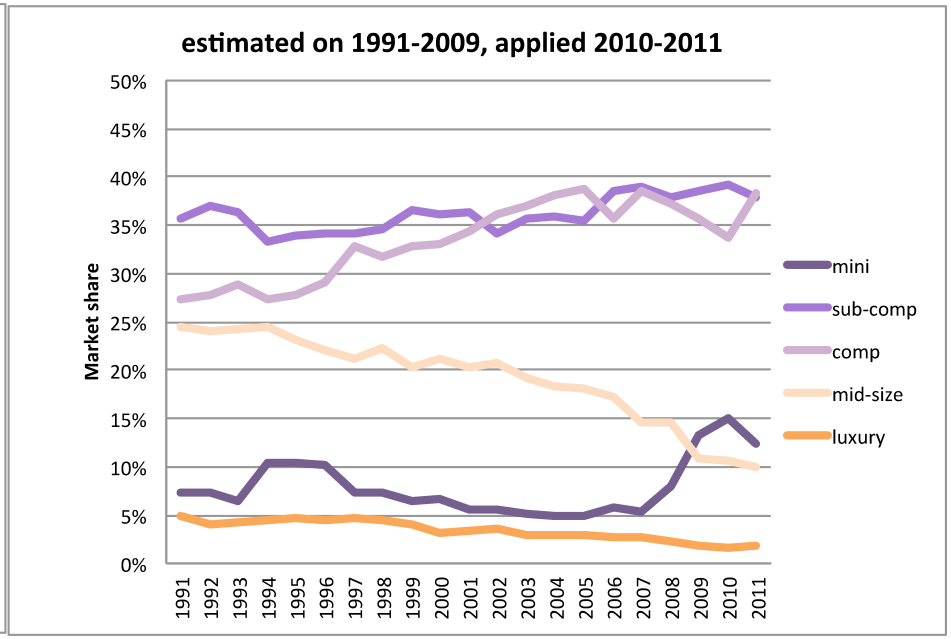




Validation of the model (holdout)

The model was applied to in-sample hold-out (last 2 years)





Validation of the model (holdout): transition matrix level

reference

	orig (row) dest (col)	mini	sub-comp	comp	mid-size	luxury
2009	mini	47.5%	42.5%	9.3%	0.7%	0.1%
	sub-comp	14.4%	66.2%	17.8%	1.6%	0.1%
	comp	5.1%	30.0%	57.0%	7.5%	0.5%
	mid-size	4.3%	18.2%	39.0%	34.8%	3.7%
	luxury	4.1%	13.6%	21.7%	24.6%	35.9%
	no car	18.3%	45.1%	26.1%	8.0%	2.4%
2010	mini	51.9%	39.0%	8.4%	0.6%	0.1%
	sub-comp	16.7%	64.5%	17.1%	1.5%	0.1%
	comp	6.1%	30.0%	56.2%	7.4%	0.5%
	mid-size	5.1%	18.2%	38.6%	34.4%	3.6%
	luxury	5.0%	13.8%	21.7%	24.4%	35.1%
	no car	21.2%	43.8%	25.0%	7.6%	2.3%
2011	mini	45.4%	43.3%	10.6%	0.7%	0.1%
	sub-comp	13.3%	65.4%	19.6%	1.5%	0.1%
	comp	4.5%	28.2%	59.9%	6.9%	0.4%
	mid-size	3.9%	17.5%	42.0%	32.9%	3.7%
	luxury	3.8%	13.3%	23.7%	23.5%	35.8%
	no car	16.9%	44.3%	28.6%	7.7%	2.4%

HO 2010,2011

	orig (row) dest (col)	origin	mini	sub-comp	comp	mid-size	luxury
2009	mini	mini	52.0%	38.2%	9.1%	0.6%	0.1%
	sub-comp	sub-comp	16.7%	63.2%	18.4%	1.6%	0.2%
	comp	comp	6.1%	28.0%	57.7%	7.5%	0.8%
	mid-size	mid-size	5.1%	16.4%	38.3%	34.1%	6.0%
	luxury	luxury	4.1%	10.6%	18.0%	20.1%	47.2%
	no car	no car	21.4%	41.8%	25.4%	7.7%	3.7%
2010	mini	mini	55.2%	36.3%	7.9%	0.6%	0.1%
	sub-comp	sub-comp	18.5%	63.0%	16.7%	1.5%	0.2%
	comp	comp	7.1%	29.3%	55.4%	7.5%	0.7%
	mid-size	mid-size	6.1%	17.3%	36.9%	34.2%	5.5%
	luxury	luxury	5.0%	11.5%	17.8%	20.7%	45.0%
	no car	no car	24.0%	42.1%	23.3%	7.4%	3.3%
2011	mini	mini	50.4%	38.8%	10.0%	0.6%	0.1%
	sub-comp	sub-comp	15.8%	62.8%	19.8%	1.5%	0.2%
	comp	comp	5.6%	26.9%	60.2%	6.6%	0.7%
	mid-size	mid-size	4.9%	16.4%	41.5%	31.3%	5.9%
	luxury	luxury	4.0%	10.7%	19.7%	18.7%	46.9%
	no car	no car	20.3%	41.6%	27.4%	7.1%	3.6%

HO minus reference

		mini	sub-comp	comp	mid-size	luxury
2009	mini	4.5%	-4.3%	-0.2%	-0.1%	0.0%
	sub-comp	2.3%	-3.0%	0.6%	0.0%	0.1%
	comp	1.0%	-2.0%	0.7%	0.0%	0.3%
	mid-size	0.8%	-1.8%	-0.7%	-0.7%	2.3%
	luxury	0.0%	-3.0%	-3.7%	-4.5%	11.3%
	no car	3.1%	-3.3%	-0.7%	-0.3%	1.3%
2010	mini	3.3%	-2.7%	-0.5%	0.0%	0.0%
	sub-comp	1.8%	-1.5%	-0.4%	0.0%	0.1%
	comp	1.0%	-0.7%	-0.8%	0.1%	0.2%
	mid-size	1.0%	-0.9%	-1.7%	-0.2%	1.9%
	luxury	0.0%	-2.3%	-3.9%	-3.7%	9.9%
	no car	2.8%	-1.7%	-1.7%	-0.2%	1.0%
2011	mini	5.0%	-4.5%	-0.6%	-0.1%	0.0%
	sub-comp	2.5%	-2.6%	0.2%	0.0%	0.1%
	comp	1.1%	-1.3%	0.3%	-0.3%	0.3%
	mid-size	1.0%	-1.1%	-0.5%	-1.6%	2.2%
	luxury	0.2%	-2.6%	-4.0%	-4.8%	11.1%
	no car	3.4%	-2.7%	-1.2%	-0.6%	1.2%

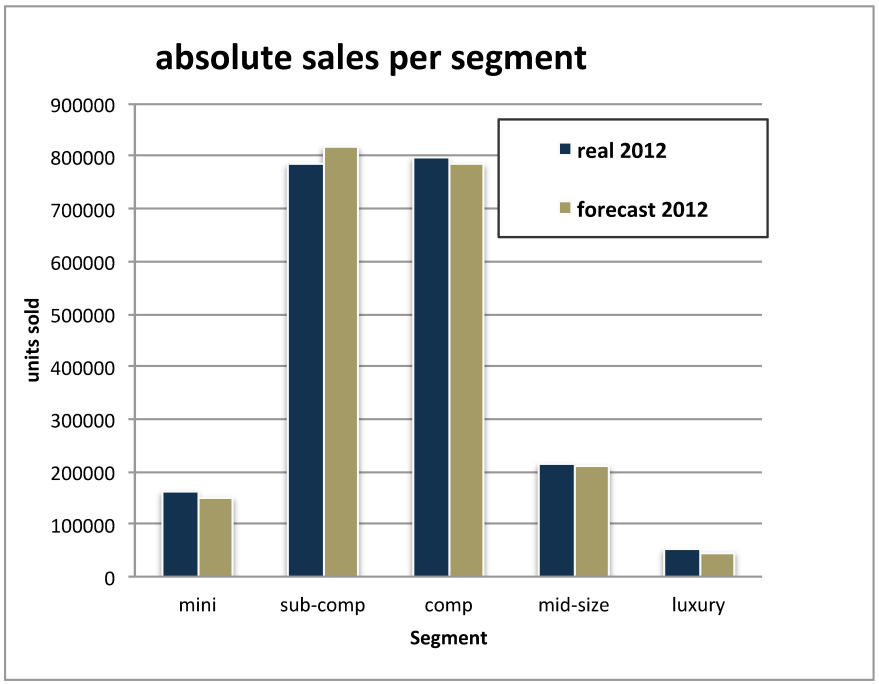
We compare the transition matrices for year 2009- 2011 (HO minus reference)

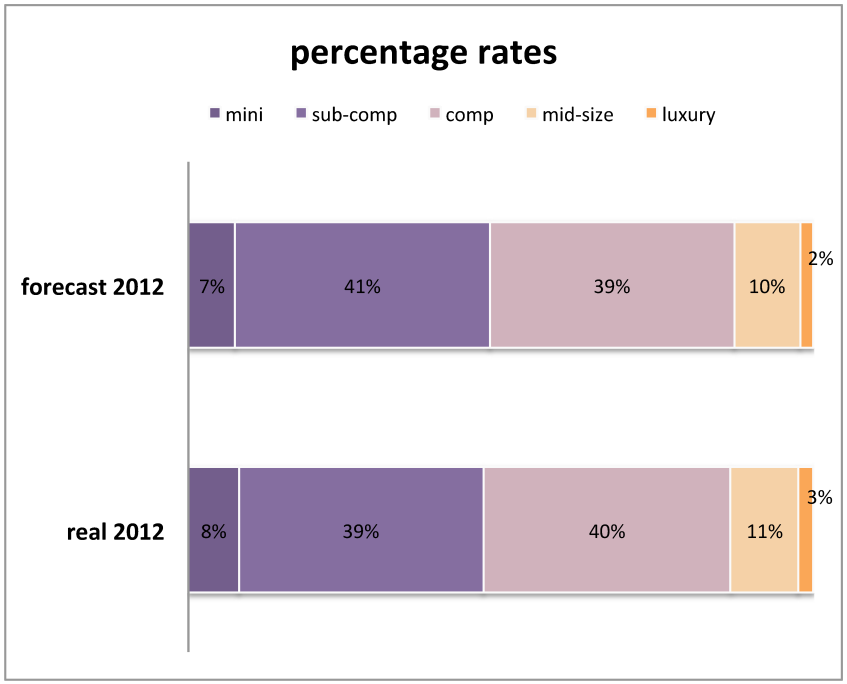
- HO overestimates the 'fidelity' in luxury
- Tends to have 2-4% of bias in allocating shifts to/from mini and sub-comp

- Observation: we struggle more with the smallest ranges

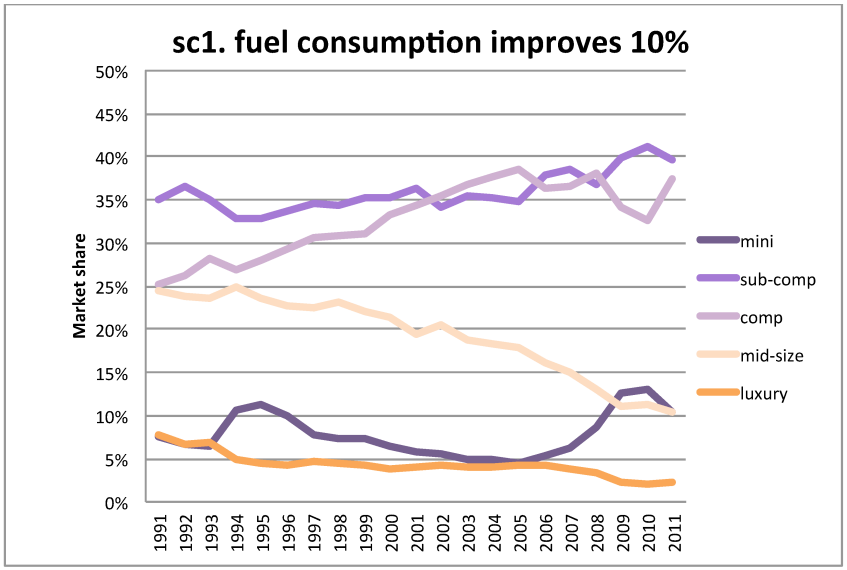
Validation on 2012 real market shares

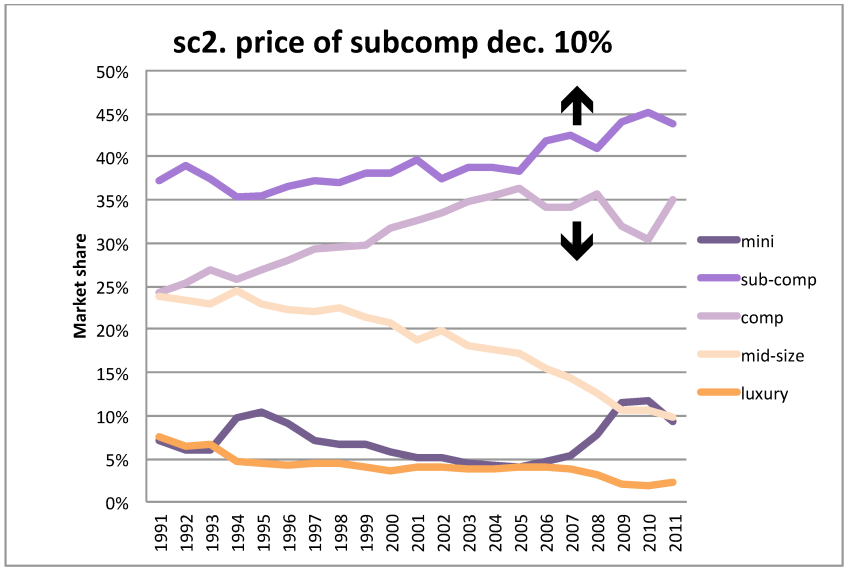
Comparison of modeled market shares against the measured 2012 market-shares

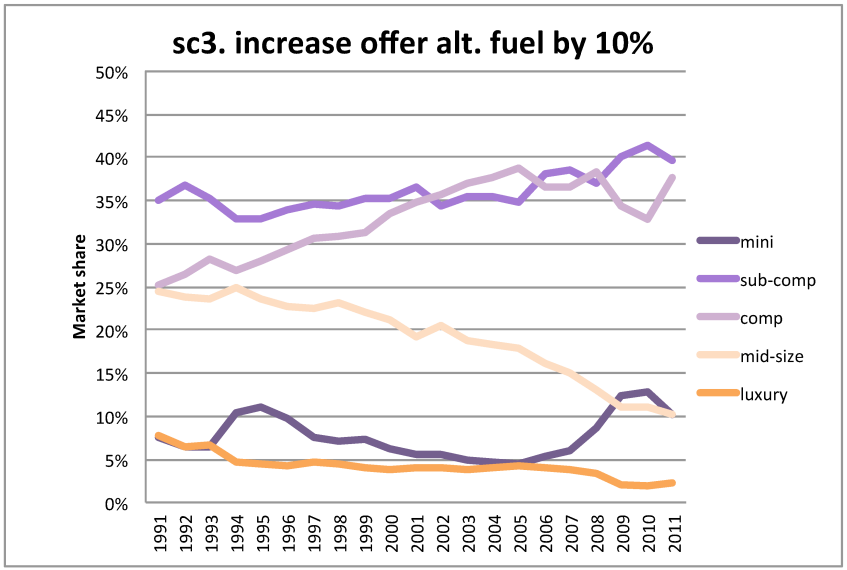


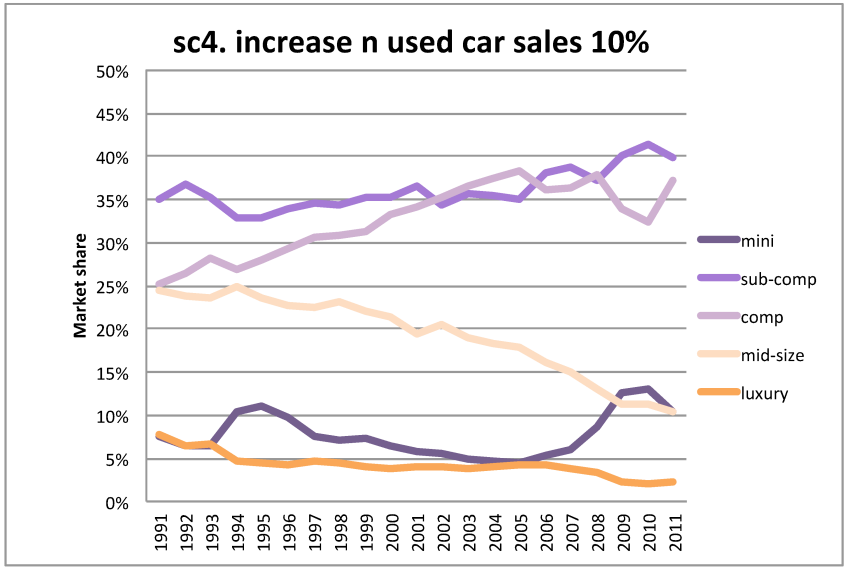


Testing scenarios

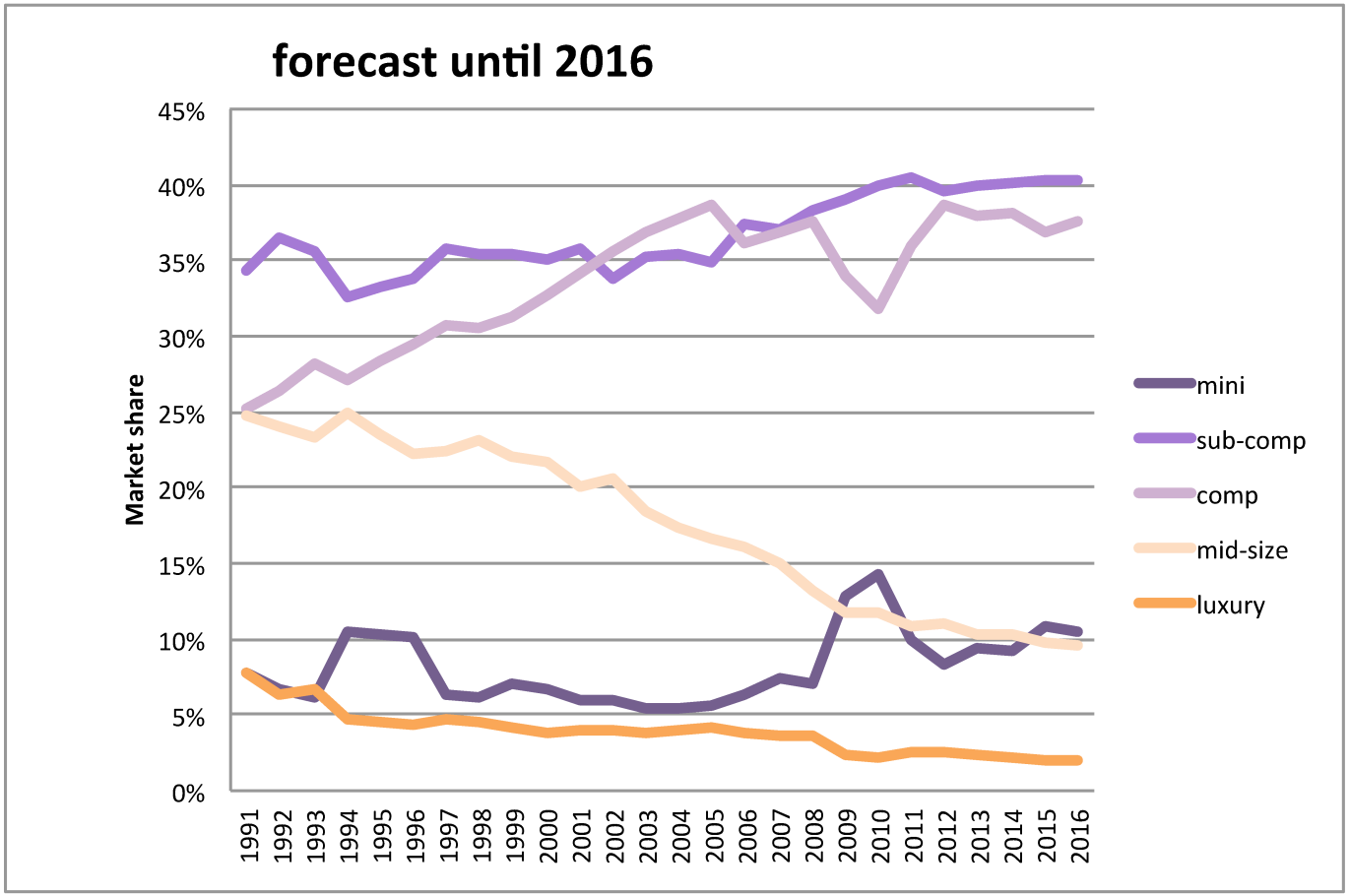








Forecasting until 2016



Variables for forecasting (5 years)	Assumption
n. car models in market (next 5 y)	planned launches projection
price of petrol at pump	Interpolate linear trend
CO2 taxation	absent
Low emission zone (%)	absent
bonus-malus	absent

Outline

Path to purchase: the case of ice-cream

Collaboration Nestlé-EPFL

- 2006–2008
- Nestlé
  - Nestlé Research Center
  - Ice cream Business Unit
- EPFL
  - Transport and Mobility Laboratory (Prof. Bierlaire)
  - Signal Processing Laboratory (Prof. Thiran)

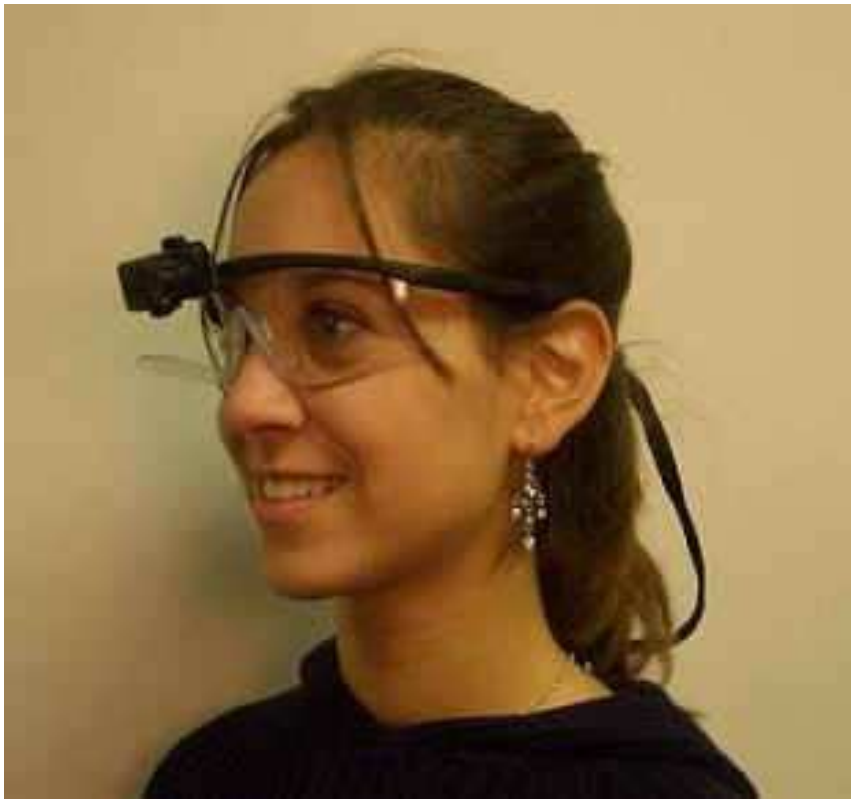
Path ro purchase

Project

- Impact of the stimuli on the consumers behavior
- Example: design of an ice cream board

Data collection

Eye tracking

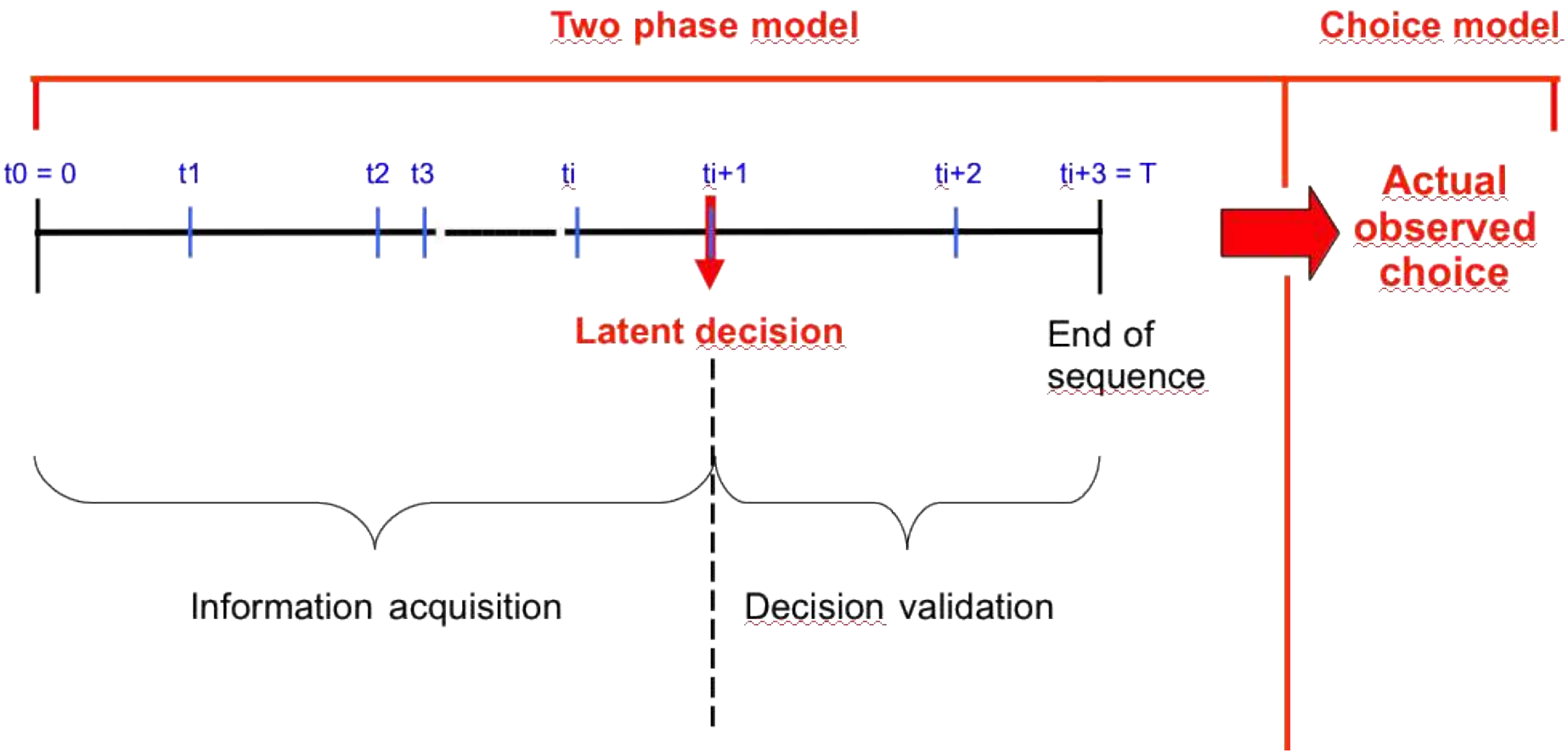


Data processing

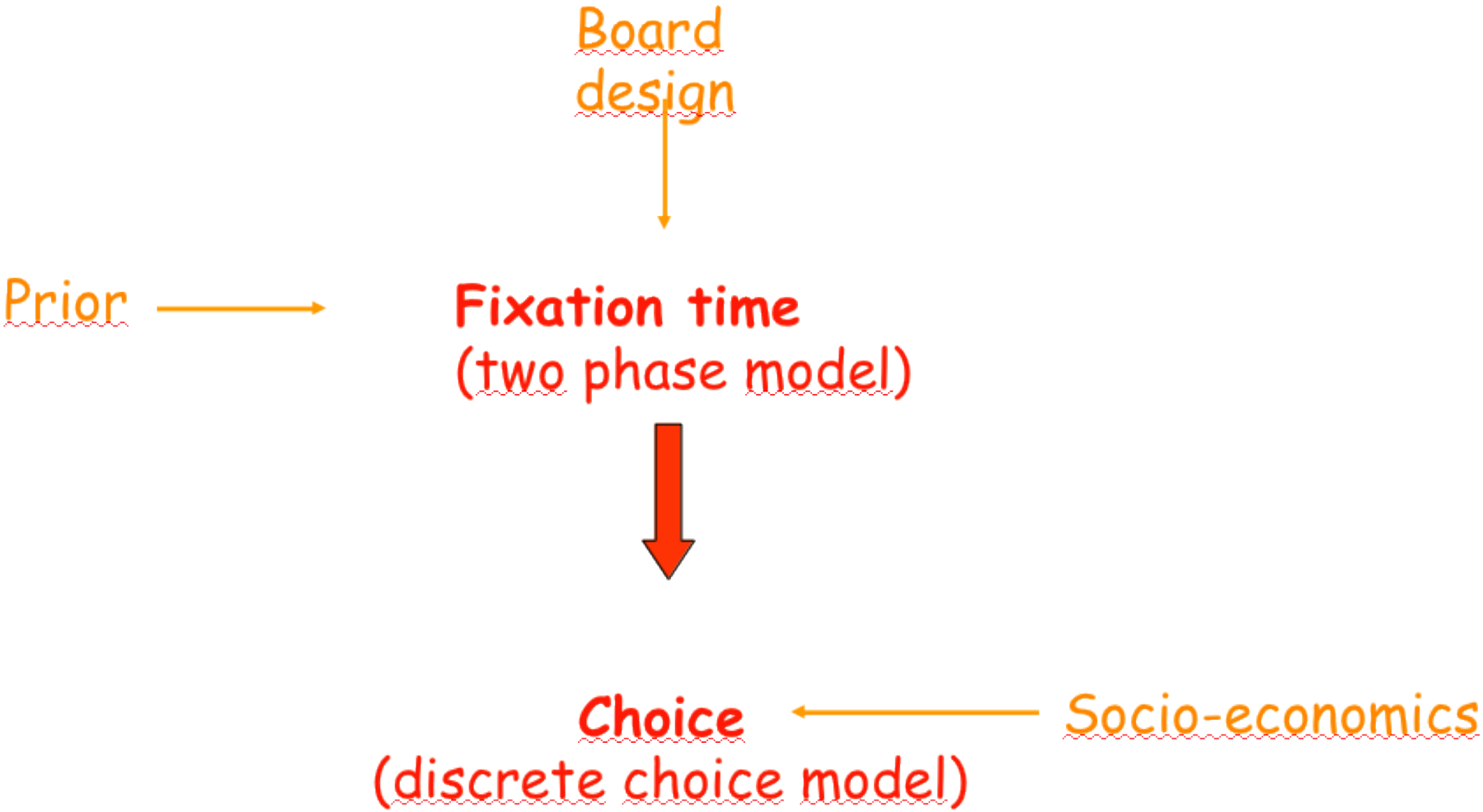
From raw video to numerical data

- Movie: Original video
- Movie: Correct distortions
- Identify locations

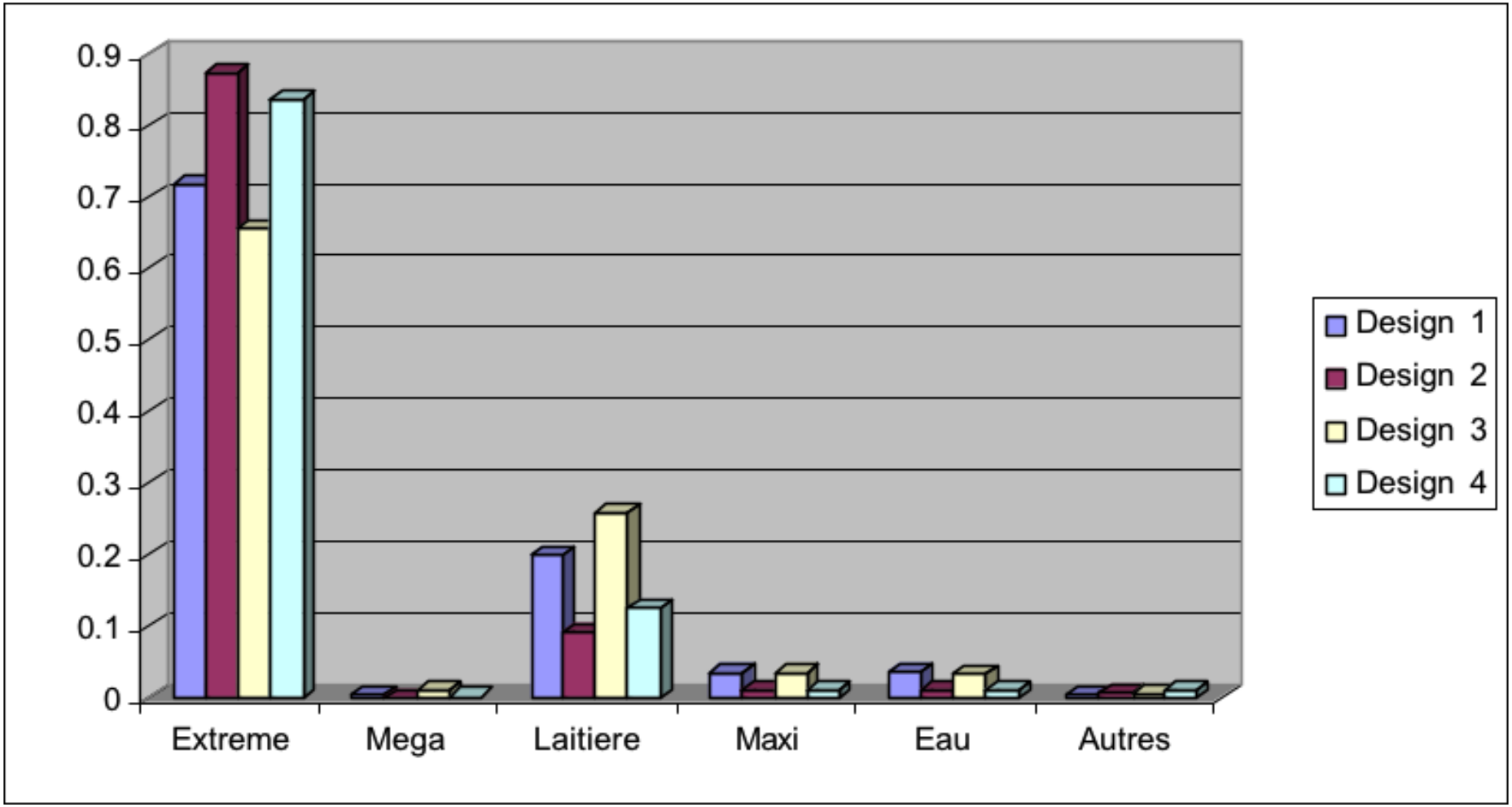
The model


Two phase model
Choice model
t0 = 0
t1
t2
t3
ti
ti+1
ti+2
ti+3 = T
Actual observed choice
Latent decision
End of sequence
Information acquisition
Decision validation

The model


Board design
Prior
Fixation time
(two phase model)
Choice
(discrete choice model)
Socio-economics

Results


0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Extreme
Mega
Laitiere
Maxi
Eau
Autres
Design 1
Design 2
Design 3
Design 4

Outline

Conclusion

Behavioral models

- Individual choice model
- Disaggregate market segments
- Flexible specification
- Quantitative and qualitative variables
- Usage of revealed and stated preferences data
- Wide range of applications
- Can account for subjectivity (attitudes and perceptions)

Short course: Discrete Choice Analysis: Predicting Demand and Market Shares

Scanner data

- March 23 – 27, 2014
- Ecole Polytechnique Fédérale de Lausanne
- Prof. Ben-Akiva (MIT)
- Prof. Bierlaire (EPFL)
- Prof. McFadden (Berkeley, to be confirmed)
- `transp-or.epfl.ch/dca`