The extended Multiple Discrete-Continuous Extreme Value (MDCEV) Model (multiple car case)

Contents

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Reto Tanner, retanner@gmx.ch

1. Scope and motivation

Examining the effects of

- i.) a fuel tax
- ii.) a tax on car ownership

on

- a.) aggregate annual mileage of cars
- b.) car ownership and the proportion of carless households
- **c.) car choice with respect to car type and thus to fuel efficiency (new!)**

2. Method

Discrete Choice Model

$$\max_i U_i = V_i + \varepsilon_i$$

U_i : Utility of product type *i*

V_i : Deterministic component

$V_i = V_i(x_i, s)$ ***"arbitrary"*** utility function, of…

x_i : Product properties

s : Sociodemographic attributes of the household

ε_i : Stochastic component. (Represents unobserved product properties, etc.)

"Choose the product type i that provides the highest utility!"

Discrete-continuous Choice Model (MDCEV)

"Which car(s) are owned and how many km's they are driven?"

$$\underbrace{\max_{S_i} u_i = u(x,\varepsilon);\ x,\varepsilon \in S_i,\ S_i \subset R_n,\ \text{eg.: } S_i = (x_1, 0, x_3, x_4, 0, x_6)}_{\text{Preferences}} \quad \text{s.t.} \quad \underbrace{\text{economic contraints}}_{\text{income and prices}}$$

$$\underbrace{x = x_i(y, p, \varepsilon);\ p,\varepsilon \in S_i}_{\text{Optimal consumption (Mashallian Demand Function)}}$$

$$\underbrace{u_i = u(x_i, \varepsilon)}_{\text{Utility}}$$

$u_i = u(x_i, \varepsilon)$ ***microeconomic*** utility function,

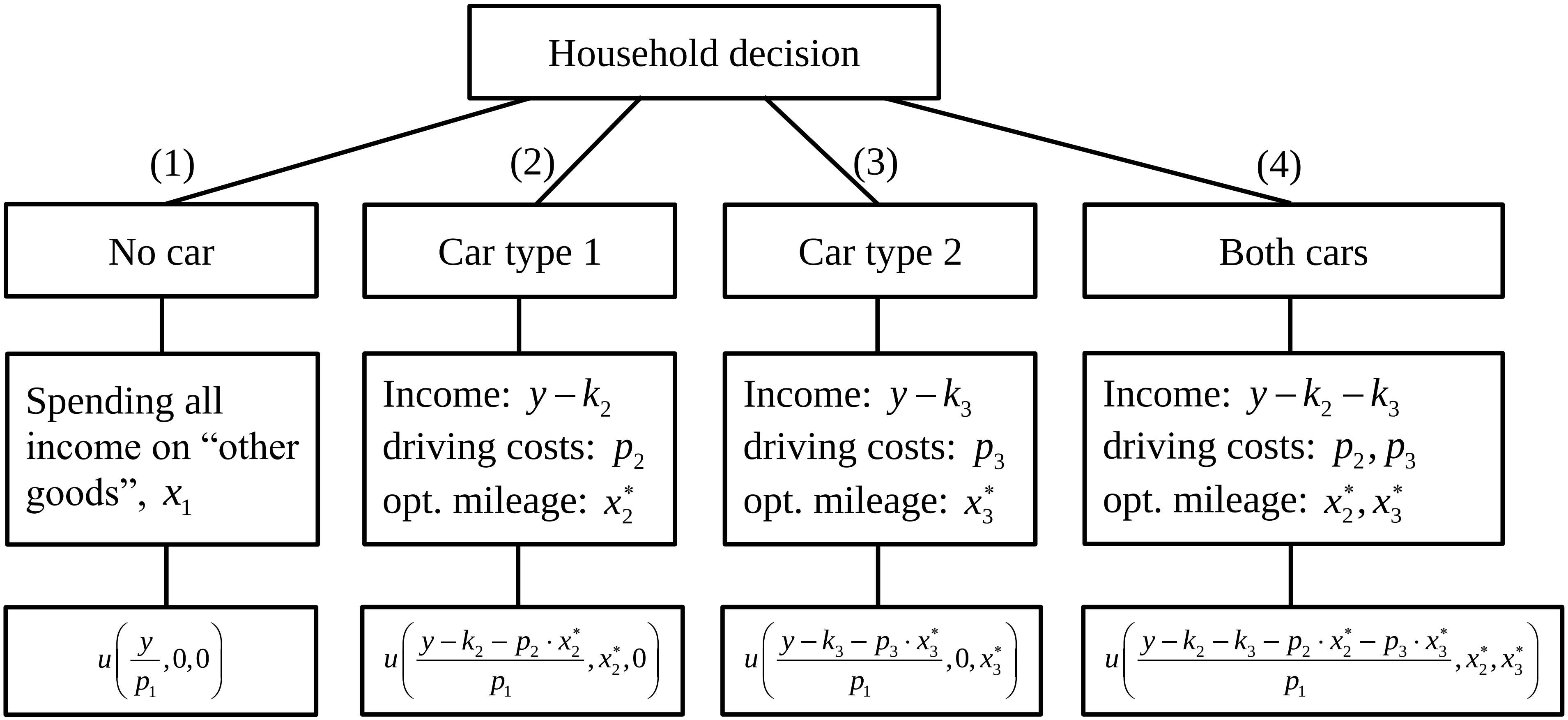
ε_i : Stochastic component. (Represents unobserved consumer preferences, etc.)

"Choose the combination of car(s) S_i that yields the highest utility!"

Remarks:

- *Why a **microeconomic** utility function?*
  - *I must relate the utility level to a driving distance*
  - *I want to make use of the properties of the microeconomic theory, here:*
    - *"Normal good":*
      - *Demand increases with income ...*
      - *... and decreases with its own price*
    - *Imposes restrictions on the demand function*
  - *Demand functions are economically consistent*
- *The utility function has a stochastic component, thus the Marshallian demand function is stochastic too*
- *This modelling framework clearly separates the effect of changes of the preferences and changes in the economic environment (income and prices)*

3. Basic idea behind the model



Choice: $\arg\max_{i=1..4}\left(u_{(1)}, u_{(2)}, u_{(3)}, u_{(4)}\right)$

4. The model (multiple car case)

$$\max_{x_1, x_2, .., x_{n+1}} \quad u(x_1, x_2, .., x_{n+1}) = (x_1 + a_1)^d + \sum_{i=1}^{n} \exp(m_{i+1} + \beta \cdot \zeta_{i+1}) \cdot (x_{i+1} + a_{i+1})^d$$

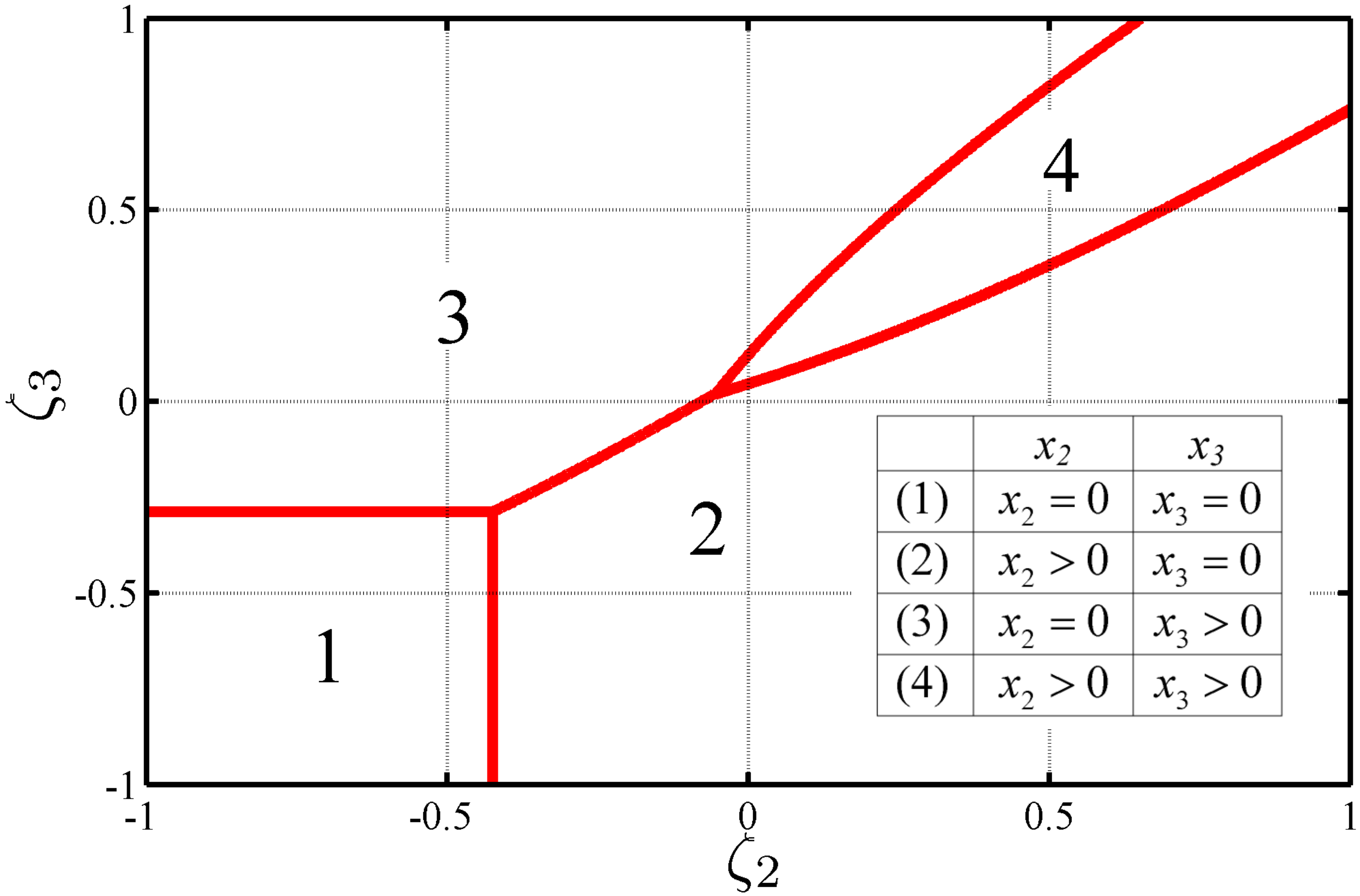
Subject to: $y = \sum_{i=1}^{n} I(x_{i+1} > 0) \cdot k_{i+1} + p_1 \cdot x_1 + \sum_{i=1}^{n} p_{i+1} \cdot x_{i+1}$,

for each possible combination of car choice, e.g. $(x_1, x_2, 0, x_4, 0, .., 0)$.

k_{i+1}:	Fixed costs of car type *i*
x_{i+1}:	Car-km with car type *i*, $i = 1..n$
x_1:	Composite good: All other goods (housing, holidays, consumption goods,…)
p_{i+1}:	Marginal costs of a car-km of car type *i* (note: $p_1 = 1$)
$m_{i+1} + \beta \cdot \zeta_{i+1}$:	Relative preference for driving car type *i*
$\beta \cdot \zeta_{i+1}$:	Stochastic component of the relative preference for driving a certain car
ζ_i:	Standard-Gumbel distributed

Example: $m_i = \gamma_{i,0} + \gamma_{i,1} \cdot rural$, where $rural = 1$ if the household lives in a rural area

5. Simulation results (two car case)



	x_2	x_3
(1)	$x_2 = 0$	$x_3 = 0$
(2)	$x_2 > 0$	$x_3 = 0$
(3)	$x_2 = 0$	$x_3 > 0$
(4)	$x_2 > 0$	$x_3 > 0$

Figure 1: Preference for certain car types and choice of car combinations

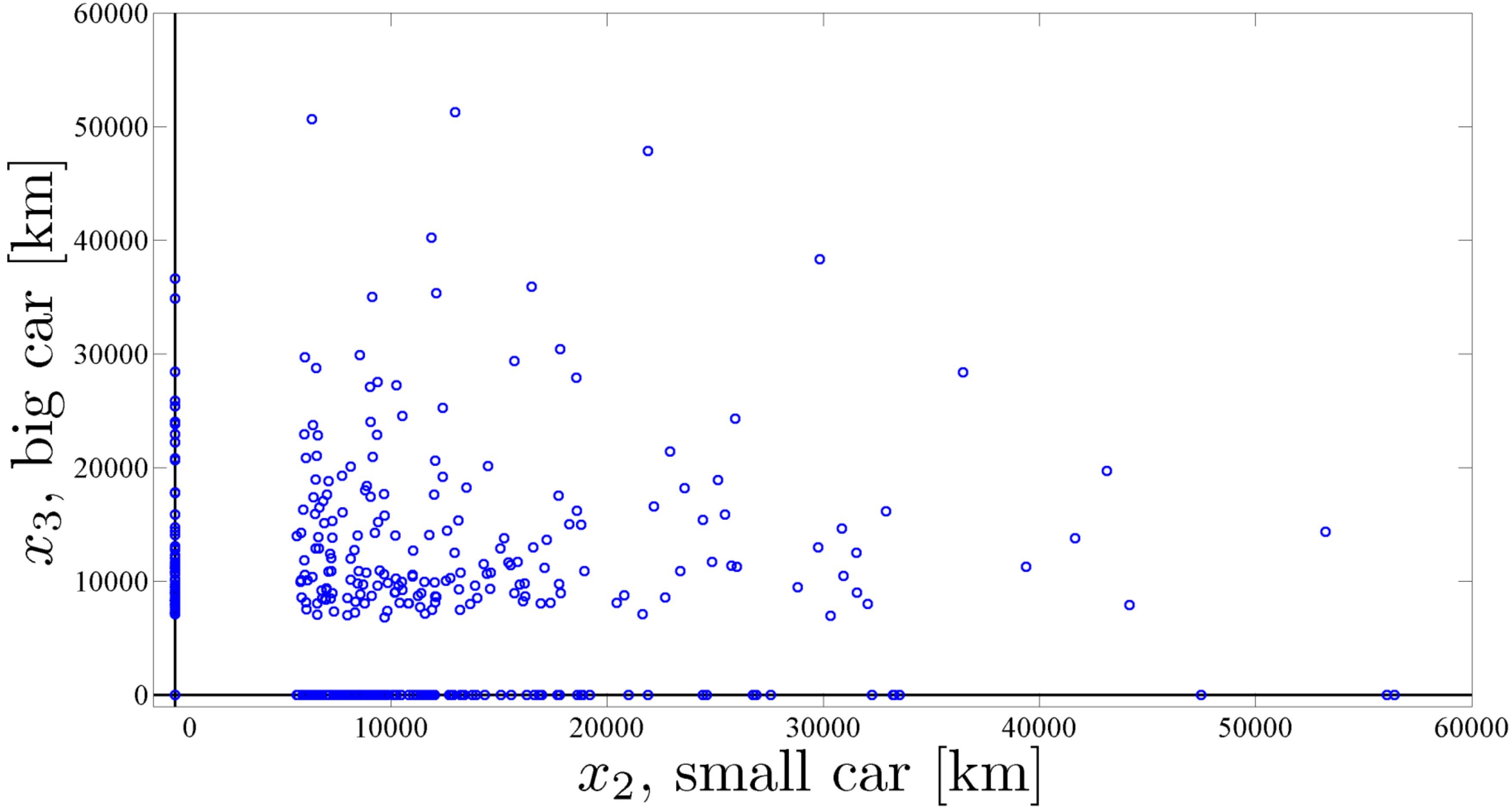


Figure 2: Simulated density function of a household with an annual income of CHF 84,000

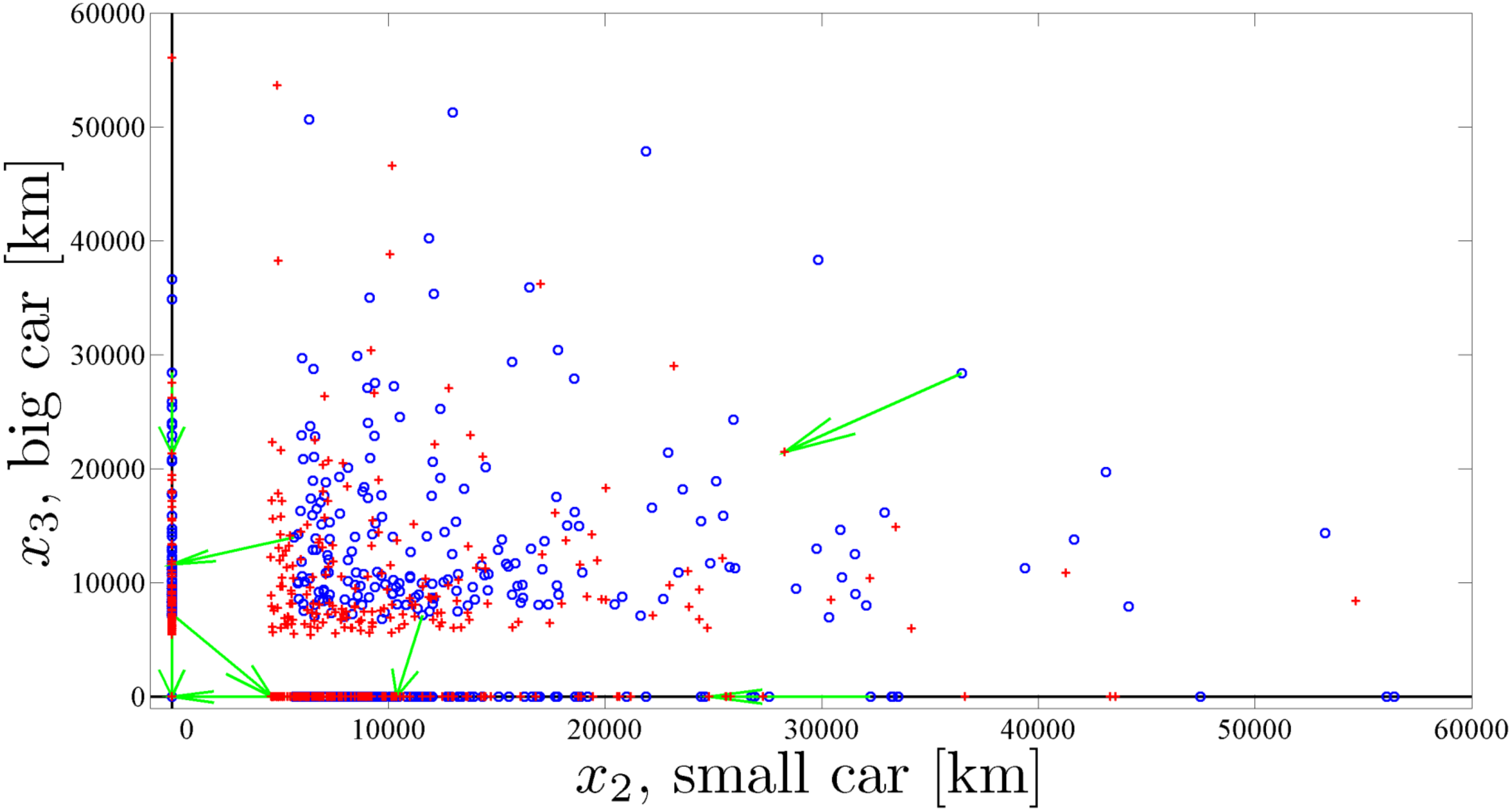


Figure 3: Simulated density function when the fuel price increases by 50%

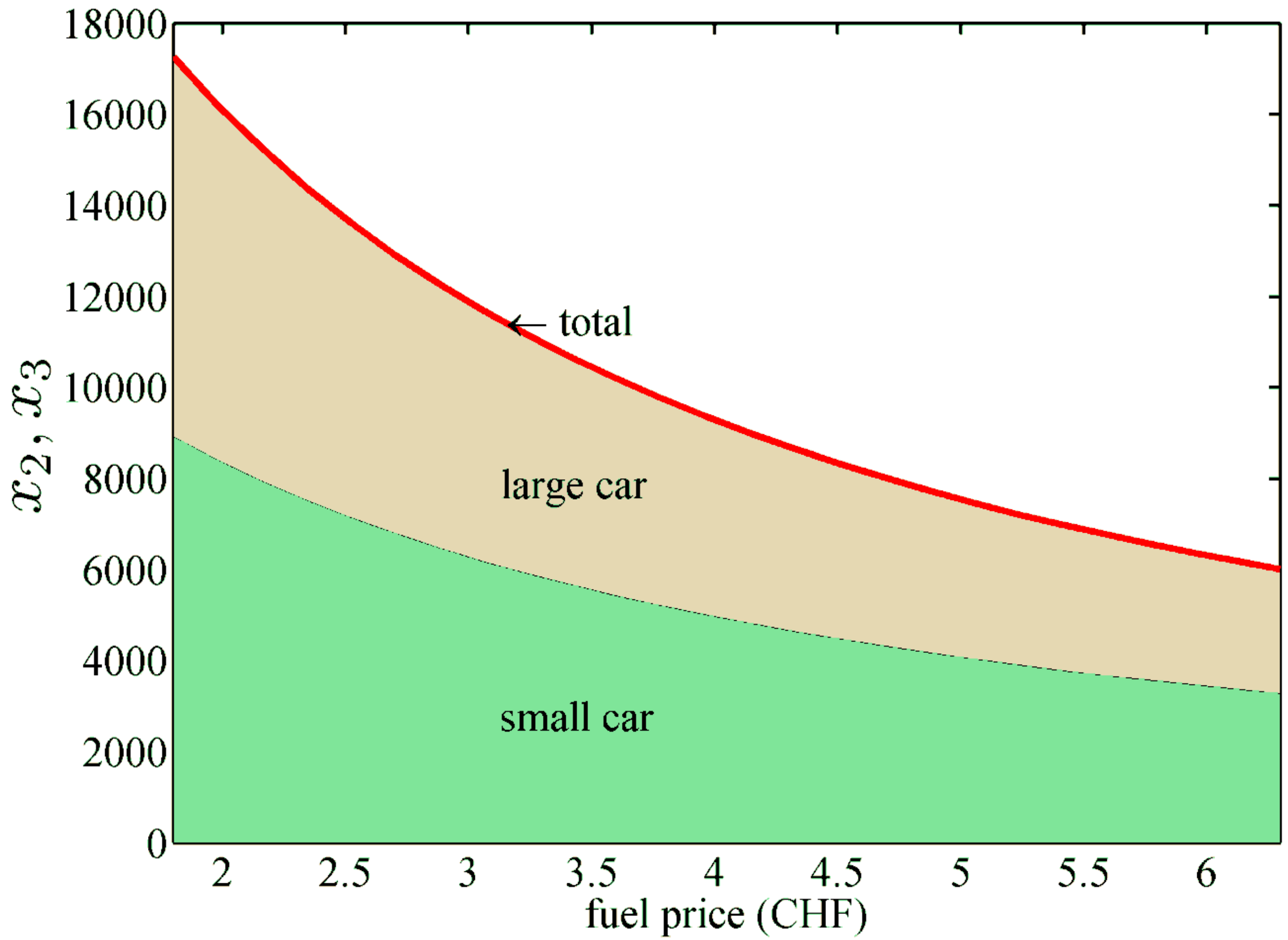


Figure 4: Change in annual mileage when the fuel price increases

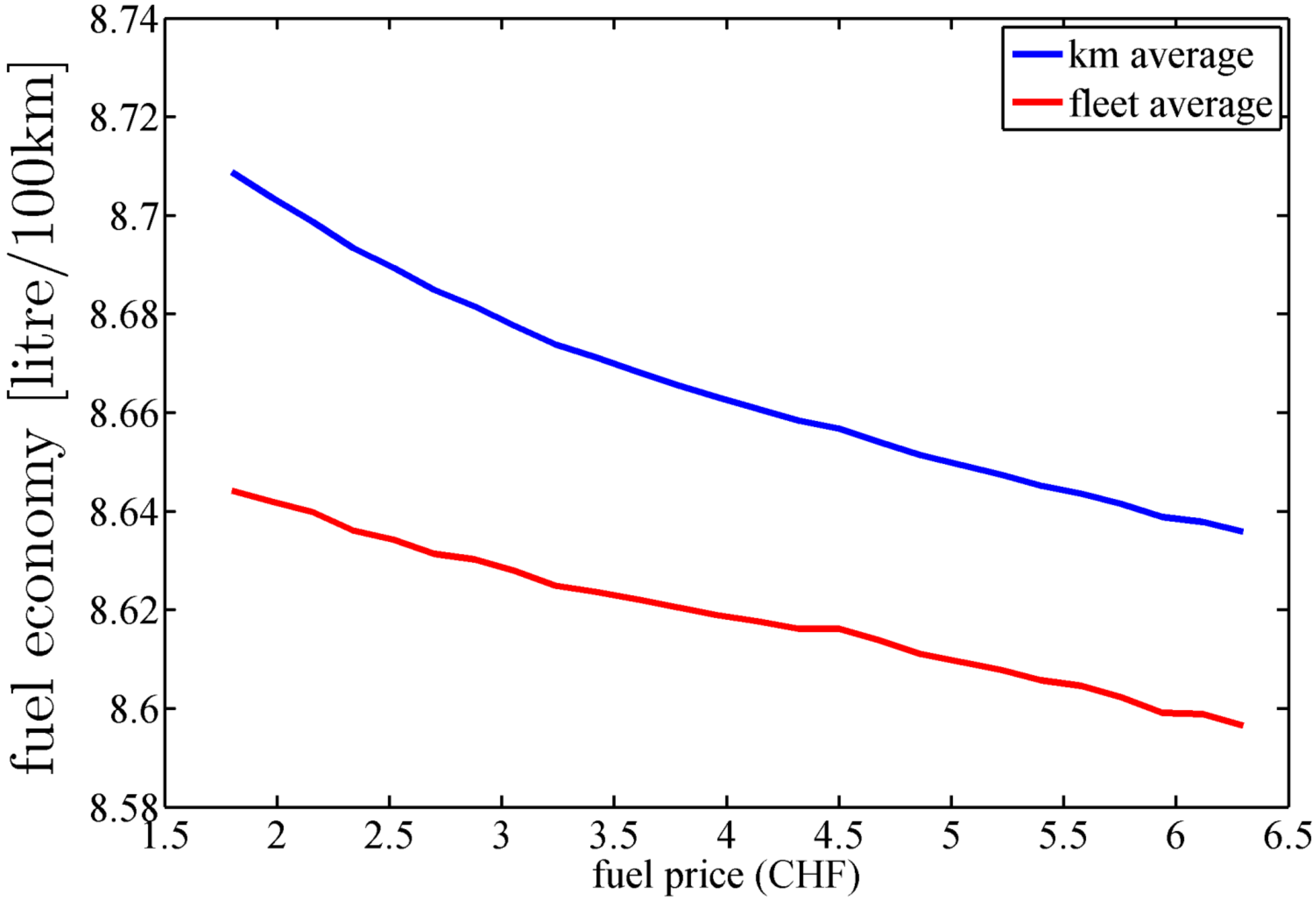


Figure 5: Change in annual mileage when the fuel price increases

6. Existing model and key results

- The existing model – the extended MDCEV model (**one car case**) – captures only one car type
- The key results are:
  - i.) the main effect of a fuel tax on the aggregate annual mileage is that “heavy users” will decrease the distance driven and not that households will sell the car
  - ii.) the effect of a fuel tax on the aggregate annual mileage is much greater than the effect of a tax on car ownership – per unit of tax revenue

7. Discussion

- Estimation routine?
- Results driven by the specification of the model structure?
- Substitutionability between car types mapped by the model?