Bilvalg under påvirkning af en skattereform og stigende brændstofpriser

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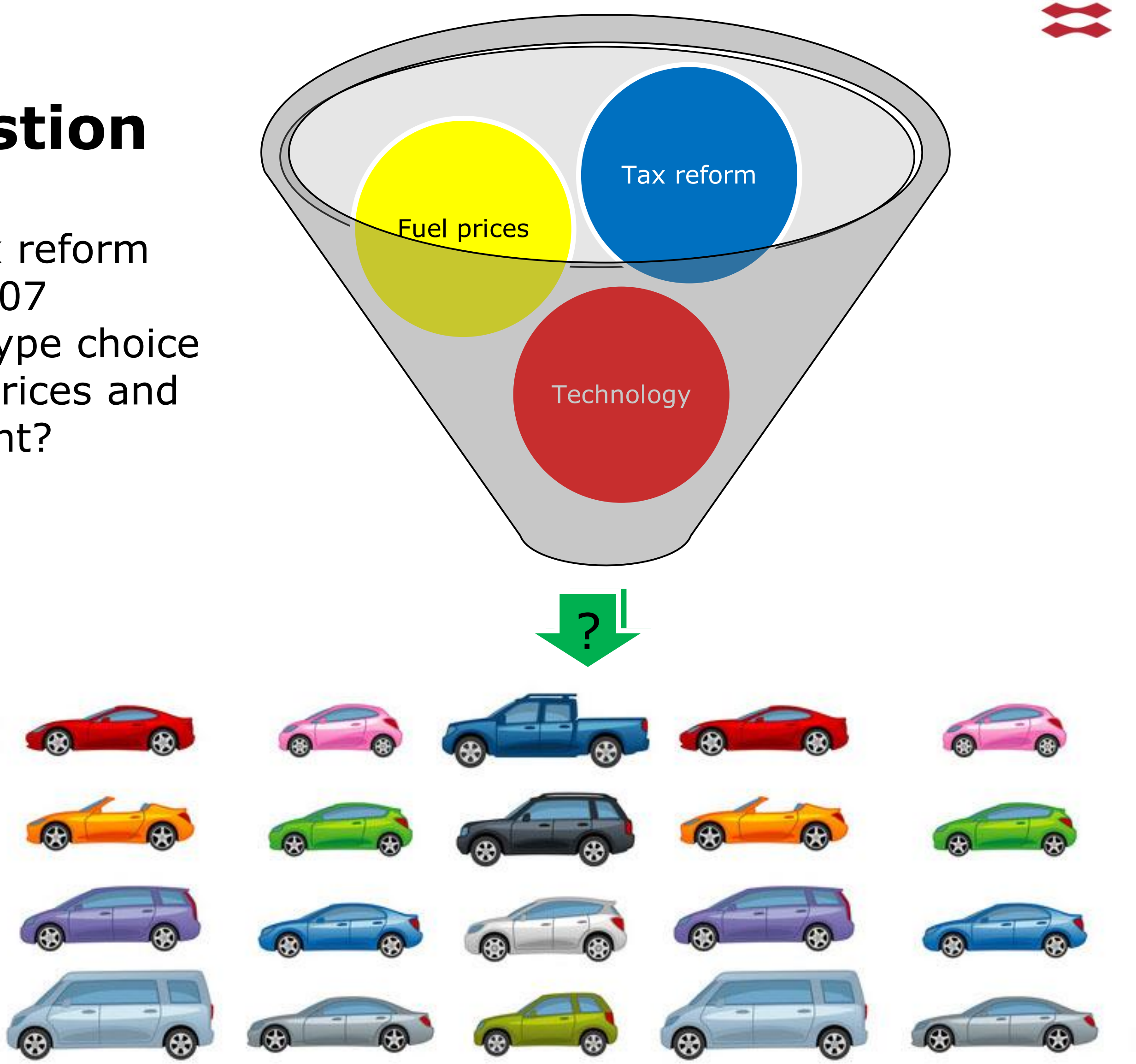
Research question

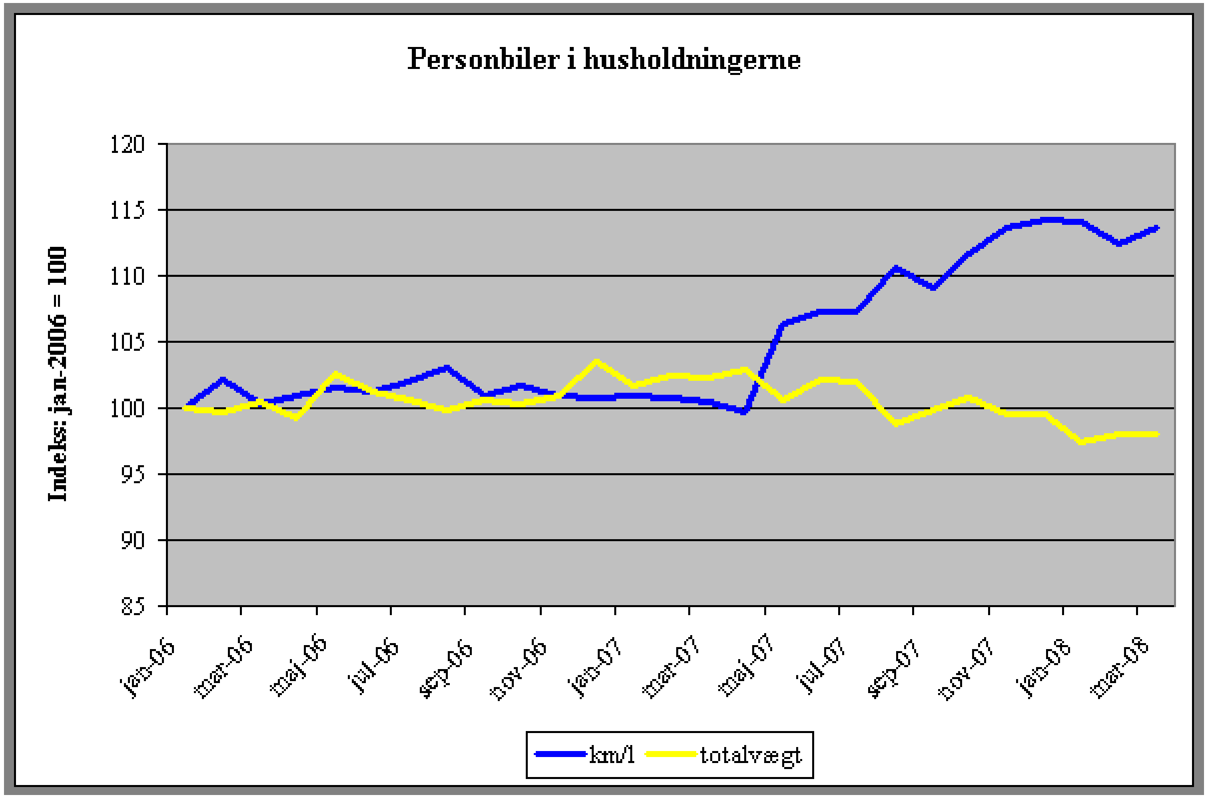
- How does a purchase tax reform (similar to the Danish 2007 reform) change vehicle type choice compared to rising fuel prices and technological development?



Outline

- Background
- Data
- Methodology
- Results
- Conclusion

New-vehicle purchases in DK around 2007



- What are the possible reasons for this change?

Background – statistics

- Descriptive statistics tell a similar story:

		Jan-Apr	May-Aug	Sep-Dec
2005	Average petrol fuel eff. (km/l)	15.2	15.1	14.9
	Average diesel fuel eff. (km/l)	20.2	20.0	19.3
	Diesel share	0.18	0.19	0.20
2006	Average petrol fuel eff. (km/l)	15.1	15.2	15.2
	Average diesel fuel eff. (km/l)	19.1	18.9	18.8
	Diesel share	0.20	0.23	0.23
2007	Average petrol fuel eff. (km/l)	15.1	15.7	16.0
	Average diesel fuel eff. (km/l)	18.6	19.8	20.0
	Diesel share	0.24	0.36	0.44
2008	Average petrol fuel eff. (km/l)	16.4	17.0	17.4
	Average diesel fuel eff. (km/l)	20.2	20.3	20.2
	Diesel share	0.42	0.40	0.36

Background – possible causes

- The changes could be a result following from
  1. The 2007 vehicle purchase tax reform
  2. Rising fuel prices
  3. Technological development of car characteristics

- Other reasons could be rising environmental concern. But this is outside the scope of this investigation.

Background – cause 1

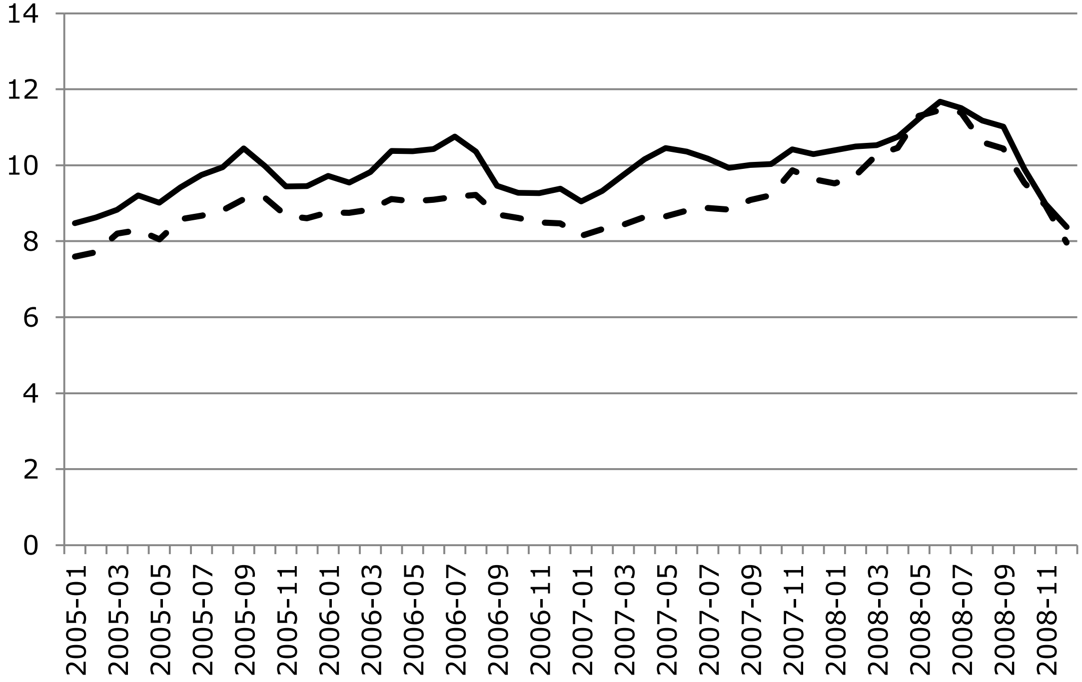
- Differentiated vehicle taxes are considered as a useful tool to promote environmental friendly vehicles.

- Such taxes have been introduced in several countries, e.g. Denmark in May 2007:
  - The tax reform used a threshold of 16 km/l for petrol and 18 km/l for diesel vehicles
  - Vehicles with fuel efficiency X km/l below the threshold became X*1000 DKK more expensive
  - Vehicles with fuel efficiency X km/l above became X*4000 DKK cheaper

Vehicle	Fuel type	Fuel eco.	Price before	Price after
Audi A6	Petrol	10.4 km/l	841,450	847,050
Peugeot 107	Diesel	24.4 km/l	140,900	115,300

Background – cause 2

- Fuel prices affect the operating costs of vehicles so rising fuel prices could affect consumers to purchase more fuel efficient vehicles



Background – cause 3

- Technological development could lead to more fuel efficient vehicles.

Attributes	2005	2006	2007	2008
Airbag4	0.40	0.46	0.79	0.84
Auto	0.18	0.17	0.24	0.22
Cost	3.59	3.61	3.80	3.73
Diesel	0.39	0.41	0.43	0.45
Doors	0.94	0.92	0.90	0.89
HPperKg	0.07	0.07	0.07	0.07
Motorsize	1.91	1.90	1.94	1.91
Operating costs	6.98	6.96	6.91	6.69
Own weight	1.33	1.34	1.36	1.35
Weight	1.89	1.90	1.93	1.92

Background – possible effects

- The factors could influence fuel efficiency and the diesel share through three effects.
    1. Households decided to buy/not buy a car
    2. Households decided to buy a new car instead of a used car
    3. Households decided to buy a different new car

- Here I study vehicle type choice, i.e. the population of new-car buyers is assumed to be fixed. This allows a detail in car alternatives that would not be possible in a more general model that could treat effects 1 and 2.

Methodology - data

- I have data on vehicle purchases in Denmark of new vehicles in 2005-2008.

- An alternative is based on make/model/fuel type/car type. This gives 341, 391, 441, and 456 alternatives in each year, respectively.

- The data include the following vehicle attributes
  - Dummies for diesel, airbag (>4), automatic, doors (>3.5), classes
  - Ln(kW per kg), Total weight, Own weight
  - Price – price ultimo each year + 4*annual tax
  - Operating costs – (fuel price expectation) / (fuel eco.)
  - Ln(No. of var.) – number of subalternatives aggregated to each alternative
- Based on Anderson et al. (2011), I assume the fuel price expectation to be captured by the price in the month prior to purchase.
- Assume that a car purchased in a given year is the newest version.

Methodology - data

- I use a 5% random sample. This gave 15195 individuals who purchased a new vehicle between 2005 to 2008.

Variable	Description	Share
Male	Dummy for male individuals	0.63
Single	Dummy for individuals who are only adult in household	0.12
Child	Dummy for individuals with children in household	0.24
Long commute	Dummy for one-way commuting distance above 25 km	0.21
No commute	Dummy for non-workers	0.06
Unk. commute	Dummy for individuals with unknown commute distance	0.21
Copenhagen	Dummy for individuals living in Copenhagen	0.19
Tri1	Dummy for purchase in the first trimester	0.34
Tri3	Dummy for purchase in the third trimester	0.30
		Mean
Income	After-tax monthly household income (1000 DKK)	35.0
Age	Age of individual	48.5

Methodology - model

- To model the vehicle purchase behaviour I apply a mixed logit model with linear-in-parameters utilities, see Train (2003) for an introduction and Mabit (2014) for the specific model.

- The model is a discrete choice model that predicts the probability of each vehicle alternative for each individual in the sample.

- The model can then predict market shares for the alternatives and other statistics, e.g. the average fuel efficiency and the diesel share.

Results - validation

- I apply the estimated model to simulated the average fuel economy and diesel share in the base scenario using another 5% random sample.

		Data	Model
2005	Average fuel efficiency (km/l)	15.63	15.70
	Diesel share (frequency)	0.20	0.21
2006	Average fuel efficiency (km/l)	15.98	15.99
	Diesel share (frequency)	0.22	0.22
2007	Average fuel efficiency (km/l)	17.03	17.01
	Diesel share (frequency)	0.34	0.35
2008	Average fuel efficiency (km/l)	18.22	18.27
	Diesel share (frequency)	0.39	0.40

Results - scenarios

- We use the model to simulated the effect of the a tax reform and rising fuel prices conditional on vehicle attributes in the various years.

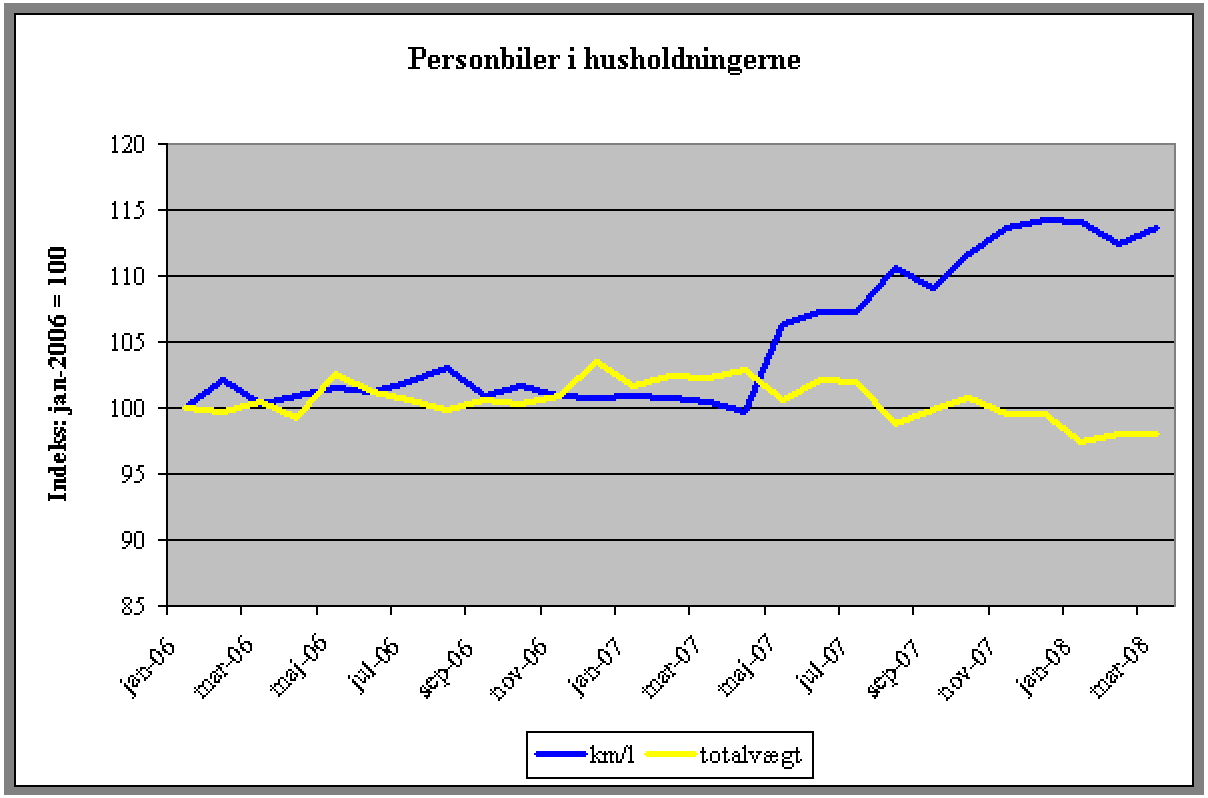
		No reform	Tax reform	Fuel prices up
2005	Average fuel efficiency (km/l)	15.64	15.91	15.88
	Diesel share (frequency)	0.20	0.22	0.23
2006	Average fuel efficiency (km/l)	15.85	16.07	16.06
	Diesel share (frequency)	0.20	0.22	0.23
2007	Average fuel efficiency (km/l)	16.76	17.07	17.02
	Diesel share (frequency)	0.31	0.33	0.34
2008	Average fuel efficiency (km/l)	17.81	18.09	18.03
	Diesel share (frequency)	0.39	0.41	0.42

Conclusion

- Simulation shows that both technological development, rising fuel prices and the assumed tax reform can affect the vehicle fleet towards higher fuel efficiency and more diesel cars.

- BUT the technological development that happened from 2006 to 2007 and again from 2007 to 2008 had an effect at least three times greater than the effect of the tax reform and rising fuel prices.

- The modelling results only reflect the effect through vehicle type choice. It would be of interest to do a similar investigation in a framework that includes also the decision to buy/not buy and the choice between buying a new or a used car.



Tak for opmærksomheden

Tak til det strategiske forskningsråd for støtte gennem ACTUM-projektet

Methodology - model

- To model the vehicle purchase behaviour I apply a mixed logit model with linear-in-parameters utilities, i.e.

$$U_{nj} = \delta_j + \beta' x_{nj} + \varepsilon_{nj}$$

where the x_{nj}'s are vehicle attributes and their interactions with socio-economic variables,
the δ_j, β are coefficients/vector of coefficients, and
the ε_{nj}'s are IID standard EV1 error terms.

- The only mixed coefficient is the cost coefficient. Following Fosgerau and Mabit (2013), we used a power series approximation which resulted in

$$\beta_n{}^c = \beta_n{}^0 + \sigma_{1,cost} u_n + \sigma_{2,cost} (u_n)^2$$

where $u_n \sim N(0,1)$.

Methodology - model

- Choice probabilities are given by

$$P_n(i|x_n) = \int \frac{\exp\left(\delta_j + \beta' x_{nj}\right)}{\sum_j \exp\left(\delta_j + \beta' x_{nj}\right)} f(\beta)d\beta$$

- The β parameters can be estimated using a maximum simulated likelihood routine assuming $\delta_j = 0 \; \forall j$.

- We have 1629 δ_j coefficients. These are calibrated using an iterative procedure

$$\delta_j{}^0 = 0 \text{ and } \delta_j{}^{r+1} = \delta_j{}^r + ln(S_j) - ln(\hat{S}_j), \quad r = 0,1,2,\ldots$$

where S_j are the market shares and $\hat{S}_j$ are the model predictions.

- This makes the model reproduce the market shares.

Results

- The model was estimated using a program written in Ox.

- All attributes were kept in the model. Interactions were only kept if significant at the 1% level.

- Loglikelihood at convergence was -81355.3 with 39 parameters giving

$$\bar{\rho}^2 = 0.111$$

Results 1/2

Variable	Estimate
Airbag	+++
Auto	+
Doors	+++
ln(HPperKg)	+++
ln(Motorsize)	+++
ln(No. of variants)	+++
Own weight	+++
Total weight	+++
Total weight * child	+++
Class1	++
Class2	+++
Class4	+++
Class5	+++
Class7	+
Class8	+++

Results 2/2

Variable	Estimate
Cost	---
Cost*Male	+++
Cost*Unemployed	---
Cost*Child	---
Cost*ln(Income/mean Income)	+++
Diesel	---
Diesel * (Age - mean Age)	---
Diesel * Male	+++
Diesel * Long commute	+++
Diesel * Copenhagen	---
Operating costs	---
Operating costs * trimester3	---
Operating costs * Male	+++
Operating costs * Unknown commute	+++
Operating costs * Long commute	---

Results - WTP

- We use the model to calculate median WTP.

Variable	Median
Airbag (DKK for more than 4 airbags)	25668
Auto (DKK for automatic transmission)	856
Diesel (DKK for diesel)	-119783
Doors (DKK for more than 3.5 doors)	14545
HPperKg (DKK per kW/kg)	683532
Motorsize (DKK per l)	29565
No. of variants (DKK for 1 more variant)	3578
Operating costs (DKK per DKK/10km)	43635
Own weight (DKK per tons)	85559
Total weight (DKK per tons)	77859
Class1	13690
Class2	29946
Class4	40213
Class5	54758
Class7	2567
Class8	40213