Introduction of “clean” cars in Sweden: an analysis of policies and their effects

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Outline

• The case of Sweden
  • Implemented policies and some effects
• Car fleet modeling
  • Existing models and results
  • Current and future work
Background

- Swedish car fleet heaviest in all Europe
- Implemented policies aim at transform the fleet to become more CO$_2$ and energy efficient by accelerating the introduction of “clean cars”
Definition of clean car

- mid-1990s: “alternatively fueled cars” (renewable fuels or hybrid)
- 2005-: “clean car” (fuel consumption, fuel type and emission level)
  - Euro 4 standard (NO$_x$, HC, CO and particles)
  - Petrol, diesel and electric hybrids that emit $< 120$ g CO$_2$ / km
  - Diesel particle filter (max 5 mg / km)
  - Ethanol E85, max 9.2 liters of petrol / 100 km
  - Biogas or natural gas, 9.7 m$^3$ of gas / 100 km
Implemented policies

- Policies to prepare the market
  - 2006-: all large refueling stations are obliged to provide at least one renewable fuel
    Approx 50% of refuelling stations have renewable fuel in 2009 (10% in 2005)
    90% of these have chosen ethanol E85
- Tax exempt for alternative fuels (ethanol, biogas, biodiesel)
Implemented policies

- Measures to make the market change
- Actors on the demand side
  - Private buyers (approx. 50% of new car sales)
  - Company cars (for private use)
    - Company owner
    - Leasing company owner
Implemented policies - National

- CO$_2$ based circulation tax
  - Base tax 36 Euros / vehicle, and 1.5 Euros / g CO$_2$ (over 100 g / km) for conventional cars and 1 Euro / g alternatively fueled cars
  - For diesel cars the tax is 3.5 times the one of a petrol car (to compensate for low fuel tax on diesel)
  - From 2009, clean car exempt for first 5 years
Circulation tax

Vehicle circulation tax

![Graph showing the relationship between CO2 emissions and yearly tax for different types of cars. The graph includes lines for petrol cars, alternative cars, and diesel cars. The x-axis represents CO2 emissions (g/km) ranging from 80 to 260, and the y-axis represents yearly tax ranging from 0 to 10,000. Each type of car has a different slope, indicating varying tax rates based on emissions.]
Implemented policies - National

- Company car benefit tax reduction
  - Worth 700-1100 Euros per year after tax
  - 20% for ethanol cars and 40% for gas or electric hybrid cars
- Subsidy (1000 Euros) for privately bought clean cars (2007-2009)
Implemented policies - Local

- Congestion charge exempt for alternatively fueled cars
  - Worth max 900 Euros per year for a regular car commuter
  - Will close 2012

- Free city residential parking for clean cars
  - In Stockholm worth approx. 70 Euros per month or 5 Euros per day
  - Closed in 2009
Supply

Clean car model supply

- E85
- Gas
- Hybrid
- Diesel
- Petrol

- 2006
- 2007
- 2008
- 2009

Supply Workshop Lausanne, August 26, 2011 – p. 11/29
New and used car sales

Sales - new and used cars

- new
- used
- scrap
- tot_sale
New car sales per fuel type

![Fuel Type Share](image)

- Gasoline
- Diesel
- Ethanol/E85
- Hybrid
- Gas
What explains ethanol car sales?

- Fuel availability; 90% of refueling stations have E85
- Prize advantage compared to petrol
E85 vs petrol prize and consumption

(Petrol prize minus E85 prize multiplied by 1.35)
What explains diesel car sales?

- 1000 Euro clean car subsidy replaced in 2009 by a 5 year circulation tax exempt
- Diesel cars more subsidized than low emission petrol cars and alternatively fueled cars

<table>
<thead>
<tr>
<th>Yearly circulation tax</th>
<th>120g CO₂</th>
<th>220g CO₂</th>
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<tbody>
<tr>
<td>Euros</td>
<td>Euros</td>
<td>Euros</td>
</tr>
<tr>
<td>Petrol</td>
<td>66</td>
<td>216</td>
</tr>
<tr>
<td>Alternative fuel</td>
<td>56</td>
<td>156</td>
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<tr>
<td>Diesel</td>
<td>208</td>
<td>680</td>
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</table>
Summary effects

- Large change of demand
- Share of clean cars: 5% in 2005 and 40% in 2010
- Mostly low emission diesel and E85 capable cars
- Flexifuel cars often driven on petrol
Summary effects

- Average fuel consumption (using petrol equivalents for E85 and gas cars)

<table>
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<tr>
<th>Year</th>
<th>l/100km</th>
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<tr>
<td>2005</td>
<td>8.0</td>
</tr>
<tr>
<td>2006</td>
<td>7.8</td>
</tr>
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<td>2007</td>
<td>7.3</td>
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<tr>
<td>2008</td>
<td>7.1</td>
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- Rebound effects: increased use because of decreased cost per km or more powerful engines at the same fuel consumption
Objectives

- Forecast the composition of the Swedish car fleet, short and long term
- Evaluate policies e.g. clean car subsidy, scrappage subsidy
Car fleet modeling

Flows 2010 and totals for December (Source: Trafikanalys)

Private vehicles in traffic
4.34 M

New registration, 0.31 M

Scrappage (real), 0.16 M
Scrappage (admin), 0.02 M
To abroad, 0.03 M

Temporary out/in traffic
Out of traffic 1.05 M
Existing models

- Scrapping
  Fixed shares per vehicle age and brand

- Car ownership (number of new cars)
  Individual based, petrol cost the only policy variable

- Car type choice
  - Nested logit
  - Three segments
  - Choice set: more than 300 car models
  - Estimated based on 2004 register data (individuals)
Existing models

- Attributes
  - Price / benefit tax
  - Running cost (fuel and vehicle tax)
  - Fuel type
  - Tank volume
  - Rust protection guarantee
  - Safety (insurance company index)
  - Engine power (hp)
  - Share of fuel stations with alternative fuel
  - Make
Existing models

- Car type choice does not take into account
  - Choice set restrictions
  - Socio-economic variables
Scenario analysis

- All private buyers get a 10000 SEK (approx. 1000 Euros) refund when buying a clean car
- Predict in 2006, share of clean cars in new car sales 2007
- Model recalibrated for 2006
Assumptions and real figures

- Assumption: number of new cars sold in 2007 equal to 2006 (100000 cars)
  Reality: 155000 cars

- Assumption: 35 new car models
  Reality: 85 new car models
# Predictions

<table>
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<tr>
<th></th>
<th>Actual</th>
<th>Original prediction</th>
<th>Corrected prediction</th>
<th>Corrected prediction</th>
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<tr>
<td></td>
<td></td>
<td>Supply</td>
<td>Supply and sales</td>
<td></td>
</tr>
<tr>
<td>Total new car sales</td>
<td>155 000</td>
<td>100 000</td>
<td>100000</td>
<td>155 000</td>
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<tr>
<td>Total number clean cars</td>
<td>28027</td>
<td>9600</td>
<td>16397</td>
<td>25416</td>
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<tr>
<td>Clean car share</td>
<td>18 %</td>
<td>10 %</td>
<td>16 %</td>
<td>16 %</td>
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<tr>
<td>Deviation %</td>
<td>0</td>
<td>-66 %</td>
<td>-41 %</td>
<td>-9 %</td>
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<tr>
<td>Deviation nb.</td>
<td>0</td>
<td>-18427</td>
<td>-11630</td>
<td>-2612</td>
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Current research

- Data
  - Register (whole car fleet) 2004-2010
  - Available alternatives (new car models/versions) 1999-2010
  - Car ownership and usage data for individuals (and households) (gender, work and home locations, number persons in household, driving licenses, income, fortune, number of cars, yearly driving distance,...)
Current research

- PhD student Shiva Habibi
- Issues related to uncertain choice sets and attributes of alternatives in future scenarios
- First step: empirical analysis
  - Definition of different models (substitution patterns) and different future scenarios
- Aggregation
Future research

- Combining car type, usage and car ownership data
- Dynamic models
- Integrate car ownership, car type choice and scrapping
- Critical issues
  - Definition of alternatives and substitution pattern
  - Modeling segments (private buyers, company owned/leased)