Who is the agent?

Politicians – Local, regional, national
Civil servants
Consultants

Private citizens
Citizen organizations
Labor organizations

Private firms
Industrial organizations
Innovators
What are the tools?

- Voluntary behavioral changes
- Pricing & regulation
- Transport operations
- ICT
- Local built environment
- Transport infrastructure
- Vehicle efficiency improvements
- New vehicle propulsion tech.
- Regional urban structures

What is the timespan?

- **Short**
  - Voluntary behavior
  - Pricing & regulation
  - Transport operations

- **Medium**
  - ICT
  - Local built environment
  - Transport infrastructure

- **Long**
  - Vehicle efficiency improvements
  - New fuel vehicle propulsion tech.
  - Regional urban structures
Example

Transforming the vehicle fleet:
1. Assessing future policies
2. Assessing past policies

Example 1

TRANSFORMING THE VEHICLE FLEET
Policy measures to change composition of car fleet

Why?
• From a theoretical point of view, why?
• Theory: transport economics and sustainability
Assume we should reduce emissions from cars
• Why should we target policy measures directly towards car fleet?
How?
• Forecasts, models

Policies

CO2-based vehicle circulation tax
Subsidy for privately bought alternatively fuelled cars
• 1 000 EUR
• Ceased 2009
Company car benefit tax reductions
• 20 percent for ethanol fuelled cars
• 40 percent for gas and electric hybrid cars
Congestion charge exempt for alternatively fuelled cars
• 0 – 800 (1 300) EUR
• Ceased 2012
Free city residential parking for alternatively fuelled cars
• 0 – 600 EUR
• Ceased 2009
Increased supply of fuelling stations with alternative fuel
Vehicle circulation tax

![Vehicle circulation tax chart]

Who buys a new car?

![Who buys a new car chart]
Company car benefit taxation

13600 (= 0.317 * Base Amount, currently 42 800)
+ 2.17 % of purchase price
+ 9 percent of purchase price up to 321 000 (7.5 BA)
+ 20 percent of purchase price over 321 000

Car price 100 000: 24 770
Car price 250 000: 41 525
Car price 400 000: 66 970

Congestion charges

Alternatively fuelled cars were exempt from congestion charges in Stockholm

The charge is differentiated during the day and varies between EUR 1 to EUR 2

The maximum fee is EUR 6 per day

The exempt may be worth up to EUR 900 per year for regular car commuters
Law on supplying renewable fuel (SFS 2005:1248)

Since 2006

1300 out of 1400 refuelling stations chose ethanol

Only 90 refuelling stations supply biogas or natural gas

And things changed…

![Fuel type shares chart]

- Petrol
- Diesel
- Electric hybrid
- Ethanol
- Gas

Percent: 0.0 - 100.0

- 2005
- 2006
- 2007
Top five selling models of clean vehicles 2008 and 2010

<table>
<thead>
<tr>
<th>Clean car model</th>
<th>Type</th>
<th>Clean car model</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volvo V70 Flexifuel</td>
<td>Ethanol</td>
<td>Volvo V70 Flexifuel</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Saab 9-3 Biopower</td>
<td>Ethanol</td>
<td>KIA CEE’D Eco</td>
<td>Diesel</td>
</tr>
<tr>
<td>Volvo V50</td>
<td>Ethanol</td>
<td>Volvo V50 D</td>
<td>Diesel</td>
</tr>
<tr>
<td>Saab 9-5 Biopower</td>
<td>Ethanol</td>
<td>VW Passat Ecofuel</td>
<td>Biogas (CNG)</td>
</tr>
<tr>
<td>Ford Focus Flexifuel</td>
<td>Ethanol</td>
<td>Renault Clio flexi fuel</td>
<td>Ethanol</td>
</tr>
</tbody>
</table>

Subsidy of 1 000 EUR when purchasing a new clean vehicle

The vehicle fleet – a slow giant!

Car fleet composition in 2015
Policy effects

CO2 emission factor down

… but what measure had most impact?

What else might have had an impact?

How to optimise the vehicle fleet policy?

Need to model vehicle fleet impact

Three models are needed for a car fleet composition forecast

Scraping model
• What cars will leave the car fleet?

Car ownership (fleet size) model
• How many new vehicles will be added?

New purchase model
• What cars will be added to the car fleet?
New purchase model variables

• Price/benefit tax,
• Size class,
• Fuel type,
• Tank volume,
• Rust protection guarantee,
• Running cost (fuel and vehicle tax),
• Safety (NCAP / Folksam classification)
• Engine power (hp) from SP study
• Share of fuel station with alternative fuel
• Brand

Policy analysis

Effects of different economic policies:
• Fuel tax
• Benefit tax
• Vehicle tax
Effects of exogenous factors:
• Fuel price
• Economic growth
• Population change
Effects of new car types
Supply assumptions

Car model development assumption

<table>
<thead>
<tr>
<th>Introduction year</th>
<th>Petrol</th>
<th>Bifuel</th>
<th>Diesel</th>
<th>Petrol hybrid</th>
<th>Ethanol</th>
<th>Diesel hybrid</th>
<th>E85 hybrid</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>328</td>
<td>2</td>
<td>49</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>380</td>
</tr>
<tr>
<td>2005</td>
<td>2</td>
<td>16</td>
<td>4</td>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>2006</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>2007</td>
<td>11</td>
<td>8</td>
<td>16</td>
<td>4</td>
<td>33</td>
<td></td>
<td></td>
<td>72</td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>2010</td>
<td>25</td>
<td>8</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>44</td>
</tr>
<tr>
<td>2012</td>
<td>1</td>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>2015</td>
<td>57</td>
<td>26</td>
<td>3</td>
<td>23</td>
<td>2</td>
<td>1</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>1</td>
<td></td>
<td>1</td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>2</td>
<td></td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>7</td>
<td></td>
<td>5</td>
<td>3</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>400</td>
<td>16</td>
<td>134</td>
<td>30</td>
<td>83</td>
<td>16</td>
<td>15</td>
<td>694</td>
</tr>
</tbody>
</table>

Continuous technological development of conventional and other techniques 1% / year

Vehicle fleet composition

Determines
- Emissions
- Running costs

Running costs -> car use
- Rebound effect
  - More efficient cars, lower costs, increased use
Rebound effects

Vehicle fleet policies → Vehicle fleet model → SAMPERS
                       National travel forecasting model
                       → Running cost per km
                       → CO2 per km
                       → Total vehicle km
                       → Total CO2 emissions

Recent application

Swedish Environmental Protection Agency
Scenarios:
• Vehicle circulation tax: stronger CO2 dependence, no reduction for alternatively fuelled cars
• Benefit taxation rules: CO2 based, no reduction for alternatively fuelled cars
• Fuel tax: strong immediate increase of tax for fossil fuels
• Fuel tax: GDP and inflation adjustment
• Combined policy: all of the above
Recent application

![Bar chart showing total CO2 emissions, million tonnes/year over time for different mesure categories and years.]

Related research issues

- Modelling car fleet evolution
  - Scrapping
  - New cars
  - Car ownership
  - Discrete choice approach

- Modelling concerns
  - Choice set formation
  - Brand loyalty
  - Unobserved random utility term correlation
  - Heterogeneous preferences
REBOUND EFFECTS

Stockholm’s Congestion Pricing

- 6.30am - 6.30pm
- 10 – 20 SEK per crossing (0.87 – 1.74 GBP)
- Max 60 SEK per day (5.24 GBP)
Stockholm’s Mix of “Green” Transport Policies

2005:
• Free Residential Parking in Central Stockholm for LEVs

2006:
• Congestion Charging Trial
• Low-Emission Vehicle (LEV) Exemption Starts

2007:
• Started National Purchase Rebate
• Congestion Charges Return, Permanently (with LEV exemption)

2008:
• LEVs are 28% of new vehicle purchases

2009:
• Stopped LEV Exemption for New LEVs
• Stopped Free Residential Parking for LEVs
• Stopped National Purchase Rebate

2012:
• Stopped LEV Exemption for Old LEVs

Greening Urban Transport

Vehicle Choice

User costs per km (-)

Travel Choices

Emissions per km (-)

Total km (+)

Total Emissions
Research Questions

How much did LEV-owners use their vehicles compared with demographically similar conventional vehicle owners in Stockholm during 2008?
How did the exemption from congestion pricing affect the use of LEVs in Stockholm during 2008?
What was the overall effect on emissions in Stockholm during 2008 due to the transition to LEVs within the fleet?
To what extent were these emissions reductions offset by rebound effects?

Data

Sweden’s Central Bureau of Statistics’ (SCB) vehicle registry data for Stockholm County, 2008

<table>
<thead>
<tr>
<th>Vehicles</th>
<th>Owners</th>
<th>Travel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make</td>
<td>Age</td>
<td>Annual Kilometers Traveled (AKT)</td>
</tr>
<tr>
<td>Model</td>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>Income</td>
<td></td>
</tr>
<tr>
<td>Propulsion</td>
<td>Home Post Code</td>
<td></td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>Work Post Code</td>
<td></td>
</tr>
<tr>
<td>Emissions</td>
<td>No. Children</td>
<td></td>
</tr>
</tbody>
</table>
Abstracted Geography of Stockholm

Northern Suburbs

Central Stockholm

Southern Suburbs

Toll Cordon

Frequencies

<table>
<thead>
<tr>
<th></th>
<th>Working inside Cordon</th>
<th>Working outside Cordon*</th>
<th>Working inside Cordon*</th>
<th>Working outside Cordon</th>
<th>All Owners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20 645 (72.43%)</td>
</tr>
<tr>
<td>Low CO₂</td>
<td>1 444 (64.5%)</td>
<td>700 (49.0%)</td>
<td>4 974 (71.0%)</td>
<td>13 627 (75.6%)</td>
<td>1 528 (5.36%)</td>
</tr>
<tr>
<td>Petrol</td>
<td>101 (5.7%)</td>
<td>99 (6.9%)</td>
<td>343 (4.9%)</td>
<td>985 (5.4%)</td>
<td>974 (3.42%)</td>
</tr>
<tr>
<td>Low CO₂</td>
<td>67 (3.8%)</td>
<td>63 (4.4%)</td>
<td>206 (2.9%)</td>
<td>638 (3.5%)</td>
<td>331 (1.16%)</td>
</tr>
<tr>
<td>Diesel</td>
<td>47 (2.7%)</td>
<td>41 (2.9%)</td>
<td>94 (1.3%)</td>
<td>149 (0.8%)</td>
<td>5 024 (17.63%)</td>
</tr>
<tr>
<td>Electric</td>
<td>415 (23.4%)</td>
<td>526 (36.8%)</td>
<td>1 386 (19.8%)</td>
<td>2 697 (14.7%)</td>
<td>28 502</td>
</tr>
<tr>
<td>Ethanol</td>
<td>1 774</td>
<td>1 429</td>
<td>7 003</td>
<td>18 296</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1 774</td>
<td>1 429</td>
<td>7 003</td>
<td>18 296</td>
<td></td>
</tr>
</tbody>
</table>

* Rebate
  - Free Parking
  - Toll Exemp.
Approach: Difference-in-Differences

Four Commuter Groups:
- A. Inner-City Worker/Residents
- B. Reverse (Outbound) Commuters
- C. Standard (Inbound) Commuters
- D. Outer-City Worker/Residents

For each Commuter Group:
- Measure Annual KM Travelled (AKT) in 2008 for LEVs
- Measure Annual KM Travelled (AKT) in 2008 for Non-LEVs
- Compute Difference between LEVs and Non-LEVs
- Compare Difference-in-Differences between:
  - A and B
  - C and D

---

Differences in Annual KM Travelled (AKT)

<table>
<thead>
<tr>
<th>Commuter Groups</th>
<th>Number of Observations</th>
<th>Average Annual Kilometers travelled (AKT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>LEV (Treated)</td>
<td>Convention (Control)</td>
</tr>
<tr>
<td>A Live/Work in Centre</td>
<td>102</td>
<td>4,605</td>
</tr>
<tr>
<td>B Outbound Commute</td>
<td>87</td>
<td>2,661</td>
</tr>
<tr>
<td>C Inbound Commute</td>
<td>216</td>
<td>18,859</td>
</tr>
<tr>
<td>D Live/Work in Suburbs</td>
<td>514</td>
<td>62,621</td>
</tr>
</tbody>
</table>
### Differences-in-Differences

<table>
<thead>
<tr>
<th>Owner Group 1</th>
<th>Owner Group 2</th>
<th>Group 1 ATT [km/year]</th>
<th>Group 2 ATT [km/year]</th>
<th>Difference in ATT [km/year]</th>
<th>Average Control Group AKT [km/year]</th>
<th>% Difference in AKT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B: Outbound Commute</strong></td>
<td><strong>A: Live/Work in Centre</strong></td>
<td>+1,576</td>
<td>+184</td>
<td>+1,391</td>
<td>13,447</td>
<td>+10.4%</td>
</tr>
<tr>
<td><strong>C: Inbound Commute</strong></td>
<td><strong>D: Live/Work Outside Centre</strong></td>
<td>+620</td>
<td>+503</td>
<td>+118</td>
<td>13,324</td>
<td>+0.9%</td>
</tr>
</tbody>
</table>

### Key Findings

- LEV owners travelled further than Conventional Vehicle owners of similar characteristics (between 1.6 and 11.2%).
- A large difference is associated with the congestion charging exemption:
  - For inner-city residents: +10.4%
  - For suburban residents: +0.9%
- Difference is due to non-work trips?
Key Findings (cont.)

- Simulated effects on emissions:
  - Assumed Flexi-Fuel used 75% E85, 25% petrol
  - Reduction due to vehicle technology: – 49.5%
  - Increase due to rebound effects: + 2.5%pt

Outlook for Research
Outlook for Policy

- LEV incentives today:
  - 2012: Super-Clean Vehicle Premium: mostly EVs & Plug-in HEVs – 40,000 SEK (R$ 14,000) for private persons
  - 2013: Exemption from annual tax for 5 years
  - 2013: Reduced tax for a company car benefit

- On Congestion Charges:
  - Expanded to Gothenburg
  - Likely revision of Stockholm
  - Other Cities? Ought exemptions be considered?

Temporary Effect?

- [Graph showing fleet penetration (green %) for Stockholm and Gothenburg, with an additional line for Stockholm without exemption.]

  - Y-axis: Fleet Penetration (Green %)
  - X-axis: Year (2006 to 2014)
Discussion

How can local and regional actors improve the effectiveness of their policies?

- Prediction?
- Cooperation amongst themselves?
- Coordination with industry?

What lessons here can be applied to other policy areas, e.g. land use/transport planning?