Direct Effects and Rebound Effects of Stockholm's Low-Emission Vehicle Incentives

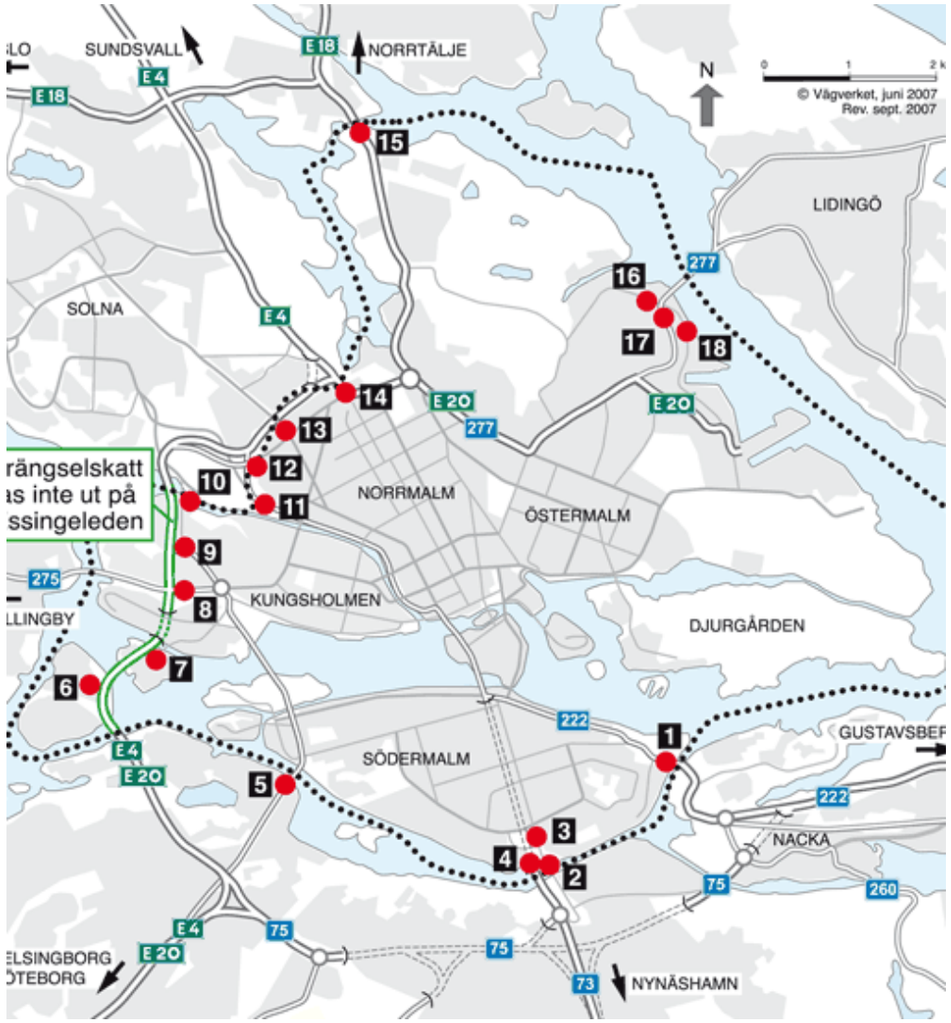
Jake Whitehead, KTH & QUT

Joel Franklin, KTH Royal Institute of Technology, Stockholm

Simon Washington, QUT, Brisbane

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**

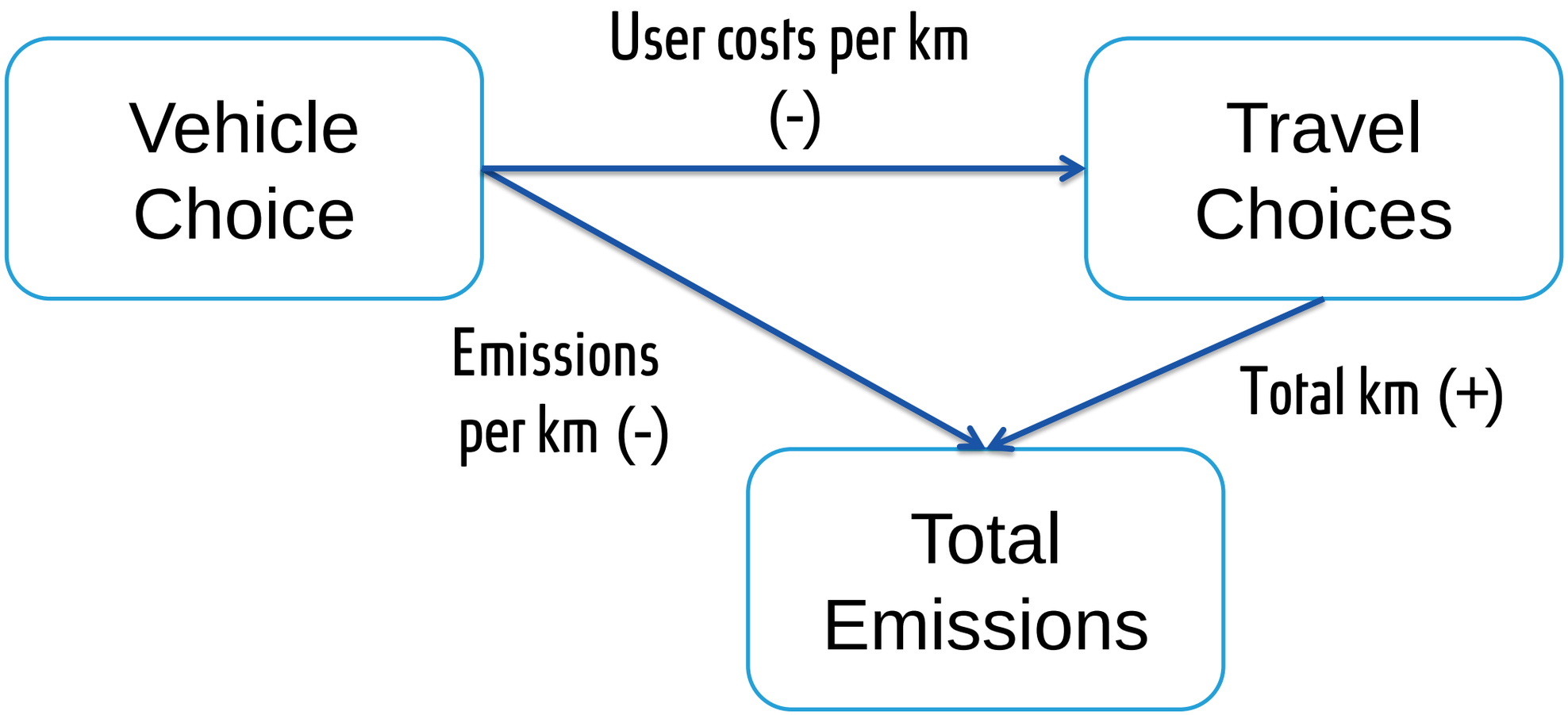
2009:

- **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



Research Questions

1. How much did LEV-owners use their vehicles compared with demographically similar conventional vehicle owners in Stockholm during 2008?
2. How did the exemption from congestion pricing affect the use of LEVs in Stockholm during 2008?
3. What was the overall effect on emissions in Stockholm during 2008 due to the transition to LEVs within the fleet?
4. 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

Vehicles

- Make
- Model
- Year
- Propulsion
- Fuel Consumption
- Emissions

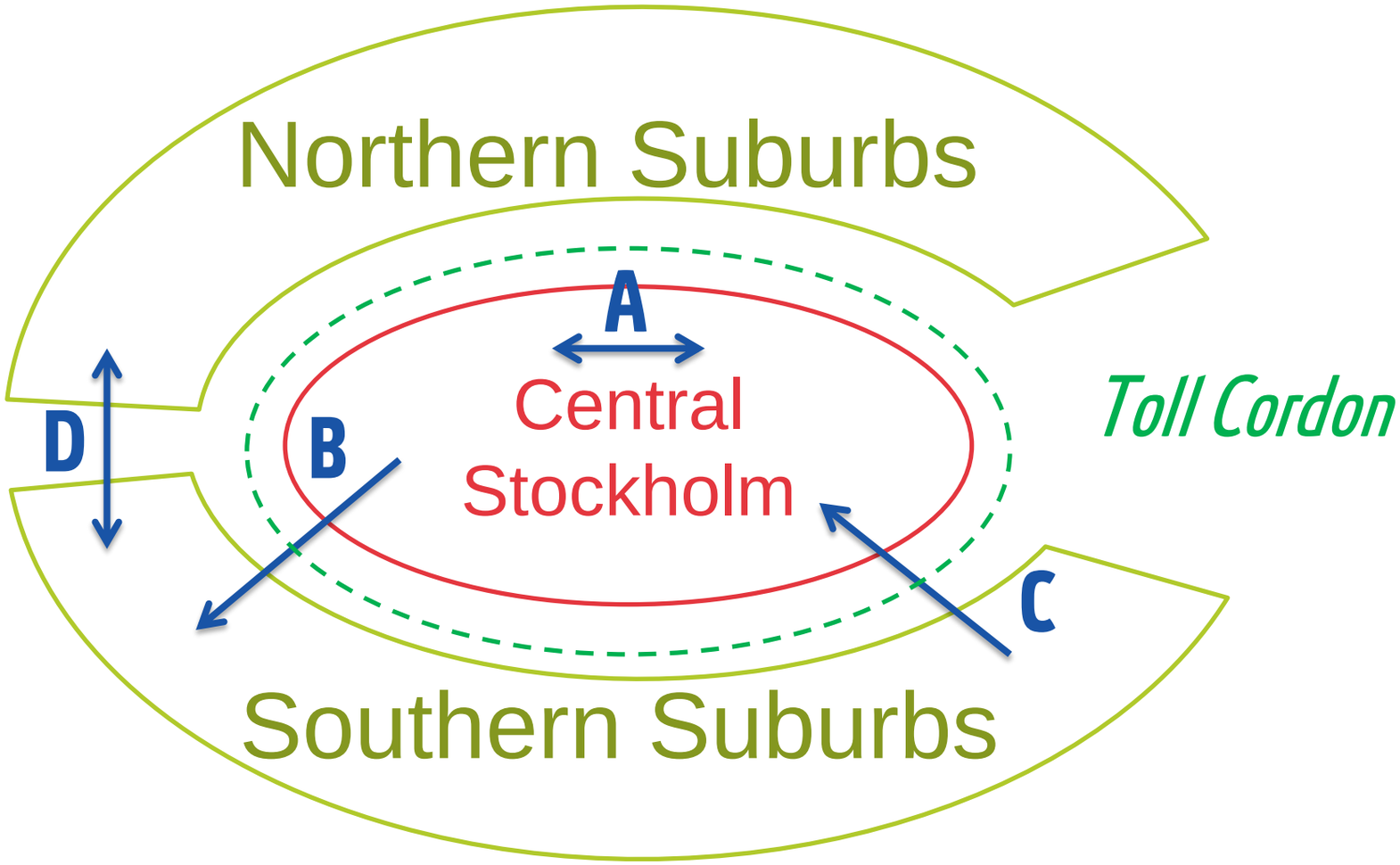
Owners

- Age
- Gender
- Income
- Home Post Code
- Work Post Code
- No. Children

Travel

Annual Kilometers Traveled (AKT)

Abstracted Geography of Stockholm



Frequencies

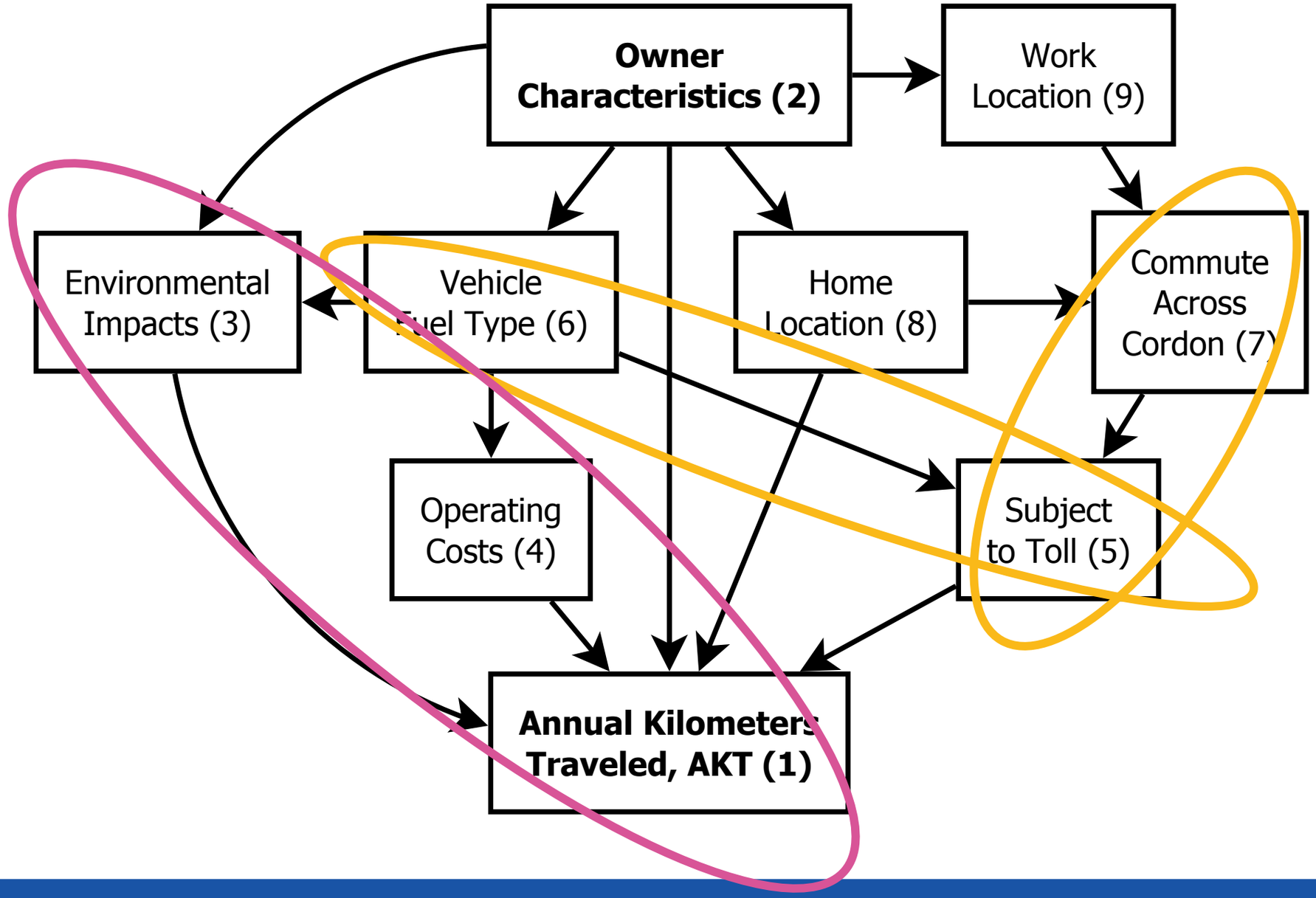
Rebate

Free Parking

Toll Exemp.

	Living inside Cordon		Living outside Cordon		All Owners
	Working inside Cordon	Working outside Cordon*	Working inside Cordon*	Working outside Cordon	
Conventional	1 144 (64.5%)	700 (49.0%)	4 974 (71.0%)	13 827 (75.6%)	20 645 (72.43%)
Low CO_2 Petrol	101 (5.7%)	99 (6.9%)	343 (4.9%)	985 (5.4%)	1 528 (5.36%)
Low CO_2 Diesel	67 (3.8%)	63 (4.4%)	206 (2.9%)	638 (3.5%)	974 (3.42%)
Electric	47 (2.7%)	41 (2.9%)	94 (1.3%)	149 (0.8%)	331 (1.16%)
Ethanol	415 (23.4%)	526 (36.8%)	1 386 (19.8%)	2 697 (14.7%)	5 024 (17.63%)
Total	1 774	1 429	7 003	18 296	28 502

Conceptual Overview



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:

1. Measure Annual KM Travelled (AKT) in 2008 for LEVs
2. Measure Annual KM Travelled (AKT) in 2008 for Non-LEVs
3. Compute Difference between LEVs and Non-LEVs
4. Compare Difference-in-Differences between:
   - A and B
   - C and D

Differences in Annual KM Travelled (AKT)

Commuter Groups		Number of Observations		Average Annual Kilometers travelled (AKT)			
Group	Commute Pattern	LEV (Treated)	Conventional (Control)	LEV (Treated) [km/year]	Conventional (Control) [km/year]	Difference [km/year]	% Difference
A	Live/Work in Centre	102	4,605	11,844	11,707	137	**1.17%**
B	Outbound Commute	87	2,661	14,692	13,447	1,245	**9.26%**
C	Inbound Commute	216	18,859	13,950	13,324	626	**4.70%**
D	Live/Work in Suburbs	514	62,621	15,094	14,590	504	**3.46%**

Controlling for Preferences: Propensity Score Matching (PSM)

Propensity Score:

- *Predicted* Propensity to Own an LEV, based on owner characteristics
  - Estimate a binary logit model for owning an LEV
  - Compute “score” as predicted probability

Matching:

- Compute Differences in AKT for “*Matched”* households, i.e. weighted by difference in Propensity Scores

Key Metric:

- “Average Effect of the Treatment on the Treated (ATT)”

Differences in AKT, after PSM

Commuter Groups			Matched Observations		PSM Results		
Group	Commute Pattern	Commuting Across Boundary	#. of treated obs.	#. of control obs.	Average effect of treatment on treated (ATT) [km/year]	Std. Error	**ATT % over Control AKT**
A	Live/Work in Centre	No	102	4,467	+184.3	539.2	**+1.57%**
B	Outbound Commute	Yes	87	2,366	+1,575.5	629.8***	**+11.72%**
C	Inbound Commute	Yes	216	18,859	+620.1	428.7*	**+4.65%**
D	Live/Work in Suburbs	No	514	62,552	+502.5	318.5*	**+3.44%**

Differences-in-Differences, after PSM

Owner Group 1	Owner Group 2	Group 1 ATT [km/year]	Group 2 ATT [km/year]	Difference in ATT [km/year]	Average Control Group AKT [km/year]	% Difference in AKT
B: Outbound Commute	A: Live/Work in Centre	+1,575.5	+184.3	+1,391.20	13,447	**+10.4%**
C: Inbound Commute	D: Live/Work Outside Centre	+620.1	+502.5	+117.60	13,324	**+0.9%**

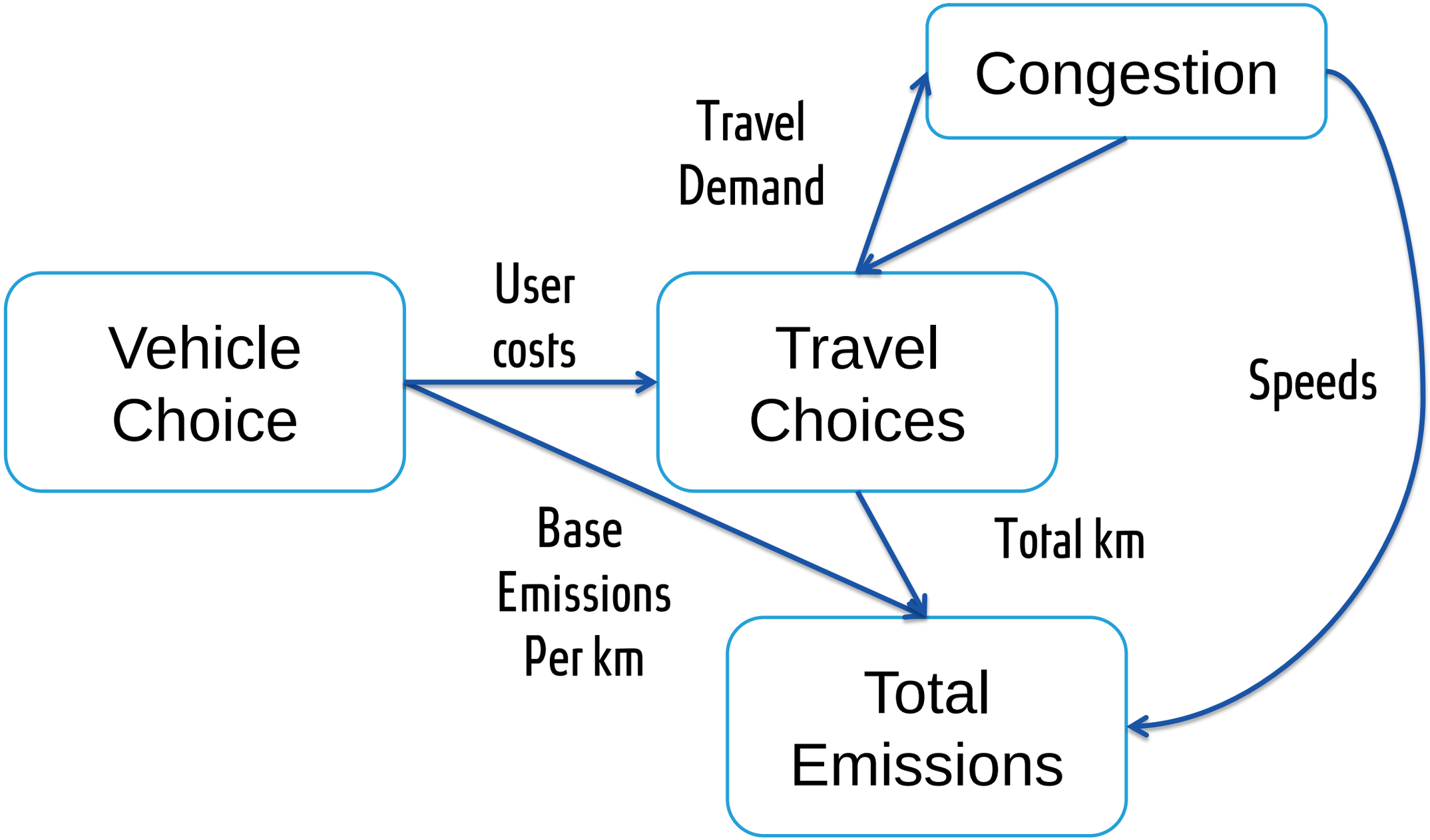
Key Findings

- 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 (£ 3500) 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?