Charging the polluters: A pricing model for road and railway noise

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VTI (Dept. of Environment and Traffic Analysis), Sweden

November 16, 2011
Background (I)

- More than 20% of the population within the EU being exposed to higher noise levels than are deemed acceptable (EC, 1996)
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- This study focus on the noise externality: “Travelers” likely to only consider the noise level inside the vehicle
Background (II)

- Infrastructure use charges based on short run marginal costs (SRMC) to address problem
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   - Traffic volume
   - Benefits transfer
   - ...
Marginal cost pricing and economic efficiency

\[ D = MB \]

\[ Q_p \]

Andersson, H (TSE)
Marginal cost pricing and economic efficiency

\[ P = MC_p \]

\[ Q_s^* \quad Q_p \]

\[ D = MB \]

\[ \tau \]

\[ a \]

\[ \text{MC}_s \]

\[ \text{MEC} \]
The short run marginal cost (SRMC)

Social cost:

\[ S = \int_0^{\infty} C(L(Q, r, X))n(r)dr \]
The short run marginal cost (SRMC)

Social cost:

\[ S = \int_{0}^{\infty} C(L(Q, r, X)) n(r) \, dr \]

SRMC:

\[ M = \frac{\partial S}{\partial Q} = \int_{0}^{\infty} \frac{\partial C(L(\cdot))}{\partial L} \frac{\partial L(\cdot)}{\partial Q} n(r) \, dr \]
The short run marginal cost (SRMC)

Social cost:

\[
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Empirical model:
The short run marginal cost (SRMC)

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SRMC:

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Empirical model:

\[ T = \sum_L c(L(\cdot))N(L)\Delta L \]

\[ c(L(\cdot)) = \frac{\partial C(L(\cdot))}{\partial L} \]

\[ N(L) = n(r)\Delta r \]

\[ \Delta L = \frac{\partial L(\cdot)}{\partial Q} \]
The 3 components of the model

1. Cost (monetary) component: $c(L(\cdot))$
The 3 components of the model

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2. Exposed individuals: $N(L)$
The 3 components of the model

1. Cost (monetary) component: \( c(L(\cdot)) \)

2. Exposed individuals: \( N(L) \)

3. Marginal acoustical effect: \( \Delta L \)
Charging the polluters

- Research area and data
- Lerum and data sources

Data sources:
1. Öhrström, et al. (2005): Noise levels and number of exposed individuals
2. Andersson et al. (2010a,b): Monetary estimates
Charging the polluters

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Railway
Road (E20)
Urbanized area

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- Emitters:
  - Road: car, bus, and truck
  - Railway: X2, X14, X60 (passenger), and Rc (freight)
  - Quiet technology: Low-noise tires and retrofitting of breaks (from cast iron to K-blocks)
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Marginal acoustical change

- A difference between road and railway is that for the latter there is usually only one source of the emission.

<table>
<thead>
<tr>
<th></th>
<th>Secondary road, 1,000 veh./24h</th>
<th>Primary road, 20,000 vehicles per 24h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>50 dB</td>
<td>70 dB</td>
</tr>
<tr>
<td></td>
<td>55 dB</td>
<td>70 dB</td>
</tr>
<tr>
<td></td>
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<td>70 dB</td>
</tr>
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- Observation where secondary sources dominate regarding road noise have been omitted $\Rightarrow$ 10% have been removed.
Distribution of “exposed”

- For the comparison of the SRMC between modes it was assumed they occupy the same corridor - the motorway corridor
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<table>
<thead>
<tr>
<th>Change</th>
<th>REBUS</th>
<th>ASEK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>w/o health</td>
<td>w/ health</td>
</tr>
<tr>
<td>Road</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>55</td>
<td>363</td>
</tr>
<tr>
<td>66</td>
<td>65</td>
<td>495</td>
</tr>
<tr>
<td>75</td>
<td>74</td>
<td>654</td>
</tr>
<tr>
<td>Railway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>55</td>
<td>24</td>
</tr>
<tr>
<td>66</td>
<td>65</td>
<td>308</td>
</tr>
<tr>
<td>75</td>
<td>74</td>
<td>3,027</td>
</tr>
</tbody>
</table>

Average exchange rate 2004: EUR 1 = SEK 9.13
## Noise tariffs calculated per vehicle and unit

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Speed km/h</th>
<th>Passengers/Freight&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Tariff, SEK/km per vehicle</th>
<th>Tariff, SEK/km per unit&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Passenger traffic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>110</td>
<td>4</td>
<td>0.06</td>
<td>0.0148</td>
</tr>
<tr>
<td>Bus</td>
<td>90</td>
<td>50</td>
<td>0.24</td>
<td>0.0048</td>
</tr>
<tr>
<td>X2 high speed</td>
<td>135</td>
<td>310</td>
<td>0.37</td>
<td>0.0012</td>
</tr>
<tr>
<td>X14 EMU</td>
<td>135</td>
<td>350</td>
<td>0.29</td>
<td>0.0008</td>
</tr>
<tr>
<td>X60 EMU</td>
<td>135</td>
<td>370</td>
<td>0.07</td>
<td>0.0002</td>
</tr>
<tr>
<td><strong>Freight traffic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck</td>
<td>90</td>
<td>42</td>
<td>0.24</td>
<td>0.0057</td>
</tr>
<tr>
<td>Truck (low noise)</td>
<td>90</td>
<td>42</td>
<td>0.08</td>
<td>0.0018</td>
</tr>
<tr>
<td>Freight train</td>
<td>90</td>
<td>1500</td>
<td>2.82</td>
<td>0.0019</td>
</tr>
<tr>
<td>F. tr. (K-blocks)</td>
<td>90</td>
<td>1500</td>
<td>0.45</td>
<td>0.0003</td>
</tr>
</tbody>
</table>

SEK price level 2004.

<sup>a</sup>: Number of passenger and metric ton of freight, respectively.

<sup>b</sup>: Per passenger and metric ton for passenger and freight traffic, respectively.
### Sensitivity analysis: Traffic and technology

**SRMC of freight per metric ton relative to a reference case of no change**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Changes as percent and dB</th>
<th>-50%</th>
<th>-25%</th>
<th>-10%</th>
<th>±0</th>
<th>+10%</th>
<th>+25%</th>
<th>+50%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-1.8dB</td>
<td>-1.0dB</td>
<td>-0.4dB</td>
<td>±0</td>
<td>+0.4dB</td>
<td>+1.0dB</td>
<td>+1.8dB</td>
</tr>
<tr>
<td><strong>Total traffic volume</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railway</td>
<td></td>
<td>0.988</td>
<td>0.994</td>
<td>0.997</td>
<td>1.000</td>
<td>1.003</td>
<td>1.006</td>
<td>1.011</td>
</tr>
<tr>
<td>Road</td>
<td></td>
<td>0.992</td>
<td>0.996</td>
<td>0.998</td>
<td>1.000</td>
<td>1.002</td>
<td>1.004</td>
<td>1.008</td>
</tr>
<tr>
<td><strong>Noise level of vehicle</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railway</td>
<td></td>
<td>0.668</td>
<td>0.801</td>
<td>0.910</td>
<td>1.000</td>
<td>1.099</td>
<td>1.248</td>
<td>1.494</td>
</tr>
<tr>
<td>Road</td>
<td></td>
<td>0.667</td>
<td>0.800</td>
<td>0.909</td>
<td>1.000</td>
<td>1.100</td>
<td>1.250</td>
<td>1.500</td>
</tr>
<tr>
<td><strong>Noise level of fleet</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railway</td>
<td></td>
<td>0.661</td>
<td>0.796</td>
<td>0.907</td>
<td>1.000</td>
<td>1.102</td>
<td>1.256</td>
<td>1.512</td>
</tr>
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<td></td>
<td>0.661</td>
<td>0.796</td>
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<td>1.000</td>
<td>1.102</td>
<td>1.256</td>
<td>1.512</td>
</tr>
<tr>
<td><strong>Number of exposed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>1.500</td>
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Railway and Road refers to a 1,500 and a 60 metric ton vehicle, respectively.
Sensitivity analysis: Monetary values

SRMC of freight per metric ton for binary changes relative to a reference case

<table>
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<th>Parameter</th>
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<th>Railway</th>
<th>Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Including health comp.</td>
<td>1.00</td>
<td>1.87</td>
<td>1.11</td>
</tr>
<tr>
<td>Switch val. road/rail</td>
<td>1.00</td>
<td>8.28</td>
<td>0.12</td>
</tr>
<tr>
<td>ASEK 4a val.</td>
<td>1.00</td>
<td>7.51</td>
<td>0.91</td>
</tr>
<tr>
<td>ASEK 4a (5 dB rail bonus)</td>
<td>1.00</td>
<td>2.21</td>
<td>0.91</td>
</tr>
</tbody>
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a: ASEK 4 refers to the official Swedish monetary noise values (SIKA, 2008).
Discussion I

- Standardized and official calculation methods and values used to develop “appropriate” and transparent estimation method for the SRMC
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  - Vehicle type (not only mode)
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  - “Time of day” (Andersson and Ögren, 2007)

Charging the polluters

Discussion
Discussion I

- Standardized and official calculation methods and values used to develop “appropriate” and transparent estimation method for the SRMC
- Charging model provides the right incentives
  - Vehicle type (not only mode)
  - Low-noise technology
  - “Time of day” (Andersson and Ögren, 2007)
- Absolute levels of the SRMC estimated in this study of limited interest
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  - Based on traffic situation and “exposed” in Lerum
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Insensitive to changes in traffic volume
Sensitive to number of exposed
Sensitive to monetary values used

Previous research have also shown that estimates are sensitive to:
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Important to examine the SRMC on both vehicle and passenger/ton of freight level.
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- The next step? Noise maps are being created for “busy areas” in the EU, but rules of thumps for number of exposed necessary to implement a model like ours
Research in progress: Area classification

Teckenförklaring
Marginalkostn, SEK/km
- 0 - 1
- 1 - 5
- 5 - 20
- 20 -

0 100 200 300 km