Infrastructure cost calculation and charging for Heavy Goods Vehicles on German motorways

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Legal framework for HGVs charging

- **Directive 1999/62/EC**
  - sets the general principles on the charging of HGVs for the use of certain infrastructure

- **Directive 2006/38/EC**
  - successor Directive
  - greater flexibility in toll differentiation
  - sets core-principles for the calculation and allocation of infrastructure costs

- **ABMG (Autobahnmautgesetz für schwere Nutzfahrzeuge)**
  - conversion of EC-Directives into German law (core-principles for HGV charging in Germany)

- **Lkw-MautV (Lkw-Maut-Verordnung)**
  - regulates operational implementation (e.g. starting date, charging system, etc.)

- **Lkw-MautHV (Mauthöhenverordnung)**
  - sets concrete charges per kilometer

- **MautStrAusdehnV (Mautstreckenausdehnungsverordnung)**
  - regulates the incorporation of some highways in the charging system
European example I: Austria (Herry et al., 2001)

- Unit replacement values by expert estimations,
- Applied to the whole inventory of roads and structures,
- Calculation of annuities,
- Stochastic survival functions,
- Cost allocation by using allocation keys derived from regression analysis.

Pros:
- Implementation simple
- Complex allocation schema

Cons:
- Sum of depreciations ≠ initial investment expenses
- Not compatible with national investment plans
- Fallacious regression, focus on capacity-demand allocation-keys
- No link to engineering knowledge
- Simple survival model
European example II: DIW method (PIM) - cost calculation

- Expenditures from (federal) budget,
- Investments aggregated into 4 homogeneous groups,
- Stochastic survival functions,
- Linear depreciation of replacement values.

Pros:
- Implementation easy, robust
- Strategic decision support (truck is cheap → investments into roads)

Cons:
- Danger to “forget” cost elements
- Disaggregation by links, road types and regions impossible
- Sum of depreciations ≠ initial investment expenses
- Possible gap between “real” and “accounted” inventory

Problematic when applied to design a tariff system:
- PPT models
- Other European frameworks
Problems with the cost allocation approach:

- Not future-oriented,
- Incentives for underinvestment and long-term inefficiency,
- Not fair,
- Latent danger that all types of overhead costs are allocated by using AASHO factors.
Basic principles of the IWW/ProgTrans approach

- **Fairness**
  - Inter-generational fairness
  - Intra-generational fairness

- **Theoretical business model**
  - Public or semi-private company

- **Efficiency**
  - Long-term efficiency

- Life-cycle consideration
- Economic depreciation
General schema of the IWW/ProgTrans approach

Scheme for infrastructure cost calculation and charging for HGV

**Inventory** of the infrastructure elements by network section and constructive element

Determining the **replacement value** by network section and constructive element for the base year 2005

Determining the **current depreciated value** by road section and constructive element for the base year 2005

Predicting the **net asset value** for the projected years by constructive element

Predicting the **reinvestments** for the projected years by constructive element

Determining and predicting the **operational costs** for the base year and the projected years

**Gross value** of fixed assets for the base year

**Net value** of fixed assets for the base year

**Depreciation and interest** for the base year and the projected years.

Determining the **total cost** for the base year and the projected years

**Allocation calculation**
The calculation approach distinguishes between the following asset categories (disaggregated approach):

- Land acquisition,
- Earthworks,
- Road layers (base layer, binder and road surface),
- Nodes (motorway, junctions and turnoffs),
- Equipment,
- Bridges,
- Tunnels,
- Motorway service areas (with or without service) and
- Maintenance depots.
Results of the disaggregated approach

German trunk road network (displayed: hilliness indicator)

Bridges of the German trunk road network (Source: BASt)
## Results of the cost calculation

<table>
<thead>
<tr>
<th>Cost components</th>
<th>Gross stock of fixed assets</th>
<th>Net stock of fixed assets</th>
<th>Age structure of fixed assets</th>
<th>Depreciation</th>
<th>Interest</th>
<th>Total cost of capital</th>
<th>Capitalised investments in maintenance</th>
<th>Running costs</th>
<th>Maintenance and running costs</th>
<th>Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Linear elements</strong></td>
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<tr>
<td>Land</td>
<td>18,10</td>
<td>18,10</td>
<td>100%</td>
<td>0.00</td>
<td>0.80</td>
<td>0.80</td>
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<td>0.00</td>
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<td>Earthworks/planning costs</td>
<td>47.34</td>
<td>27.52</td>
<td>58%</td>
<td>0.96</td>
<td>1.22</td>
<td>2.18</td>
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<td>0.00</td>
<td>2.18</td>
<td>2.18</td>
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<td>Base layers</td>
<td>12.45</td>
<td>7.50</td>
<td>60%</td>
<td>0.19</td>
<td>0.33</td>
<td>0.52</td>
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<td>0.00</td>
<td>0.52</td>
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<tr>
<td>Road surface 1)</td>
<td>9.22</td>
<td>5.20</td>
<td>56%</td>
<td>0.35</td>
<td>0.23</td>
<td>0.58</td>
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<td>0.58</td>
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<td><strong>Point based objects</strong></td>
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<tr>
<td>Installations 2)</td>
<td>18.84</td>
<td>9.42</td>
<td>60%</td>
<td>0.85</td>
<td>0.42</td>
<td>1.27</td>
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<td>Nodes 3)</td>
<td>18.95</td>
<td>17.75</td>
<td>94%</td>
<td>0.19</td>
<td>0.79</td>
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<td>Tunnels</td>
<td>4.14</td>
<td>3.46</td>
<td>84%</td>
<td>0.01</td>
<td>0.15</td>
<td>0.16</td>
<td>0.04</td>
<td>0.00</td>
<td>0.20</td>
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<td>Bridges</td>
<td>31.42</td>
<td>19.57</td>
<td>62%</td>
<td>0.27</td>
<td>0.87</td>
<td>1.14</td>
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<td>Maintenance depots</td>
<td>0.64</td>
<td>0.45</td>
<td>70%</td>
<td>0.01</td>
<td>0.02</td>
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<td>0.00</td>
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<tr>
<td>Service areas and lay-bys</td>
<td>8.42</td>
<td>5.17</td>
<td>61%</td>
<td>0.07</td>
<td>0.23</td>
<td>0.30</td>
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<td><strong>Operation</strong></td>
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<td>Operational Costs 5)</td>
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<td>0.60</td>
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<td>0.60</td>
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<tr>
<td>Administration and police 6)</td>
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<td></td>
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<td>0.94</td>
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<td>Toll system</td>
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<td>0.84</td>
<td>0.84</td>
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<tr>
<td><strong>Total</strong></td>
<td>169.52</td>
<td>114.13</td>
<td>67%</td>
<td>2.90</td>
<td>5.06</td>
<td>7.96</td>
<td>0.23</td>
<td>2.37</td>
<td>2.50</td>
<td>10.57</td>
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</table>

1) road surface and binder, where applicable - 2) Also includes noise barriers - 3) Additional land use at junctions and exits and their branches - 4) underpasses, retaining walls and traffic sign bridges - 5) Landscaping, winter maintenance and traffic safety measures – 6) costs borne by the federal states

### Total cost of the federal motorways 2007 (in billions of Euro)

Total cost: 10.57
Cost allocation principles of the IWW/ProgTrans approach

- **Total infrastructure cost** = sum of the cost of all links and nodes,

- **Cost of each link** = sum of the cost of all structures belonging to the link,

- **Cost of each structure consists of**,
  - Short term variable cost,
  - Traffic load dependent fixed cost,
  - Basis cost.

- **Minimization of total cost** = minimization of cost for all structures according to life cycle cost considerations,

- **Allocation of total cost** inspired by Shapley formula
  - Incremental cost,
  - Uniform and capacity-dependent allocation keys,
  - AASHTO.
Facilities of the approach:
- compatible with CBA,
- principles of engineering decision making fulfilled,
- International Accounting Standards,
- Difficult to manipulate (disaggregated approach).

Future oriented approach,

Gives right incentives for efficient investments,

Methodology is suited for:
- changes in business model,
- regulation of private operators,
- detailed sub-network analysis.

Applicable for:
- railway networks and airports,
- energy transmission grids,
- telecommunication networks.
Feedbacks are welcome!!

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