Methods, Inputs and Examples for Future Transport Volume Prognosis in Germany

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HICL 2012
Designing the Future Supply Chain

TUHH - Hamburg
1. Introduction

2. Existing Prognosis

3. GAMS

4. Conclusion / Outlook
1. Introduction

- World Economic Crisis 2008/2009 has shown…
  - the potential weakness of financial and industry sector
  - the high volatility of logistics demand and transport volume
  - specific areas of logistics losses up to 17.2%

### Total Transport Volumes in Germany [million tkm]

<table>
<thead>
<tr>
<th>Year</th>
<th>Volumes [million tkm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>655.479</td>
</tr>
<tr>
<td>2009</td>
<td>581.881</td>
</tr>
<tr>
<td>2010</td>
<td>619.854</td>
</tr>
<tr>
<td>2011</td>
<td>643.810</td>
</tr>
</tbody>
</table>

Δ 11.2%
The income elasticity of manufactured exports is higher than that of total merchandise exports.

In other words, trade in manufactured goods responds more than merchandise exports to changes in income.

From 1960 to 2008, the average elasticity for total merchandise was 1.7, but for manufactured goods it was 2.1.
2. Existing Prognosis

- Economic development indicator

Based on qualitative interviews with executives from 100 German companies.

Risk of self-fulfilling prophecies: same group asked every 3 months.
2. Existing Prognosis

Background:
- Reduction of CO₂ emissions, climate goals of the FRG & EU
- High proportion of logistics on GHG emissions
- Opposing development of transport (increase)
- Short- and medium-term dependence on fossil fuels

Is it possible to calculate a future transport mix with GAMS which take the contrary conditions into account?
GAMS - General Algebraic Modeling System

- Preparation / data collection:
- CO$_2$ emissions in 2025:
  - EU White Paper 2009: cutting emissions till 2020 to 80% of levels by 1990
  - EU White Paper 2011: reduce emissions to 60% till 2025 (baseline 2004)
- Determine increase in traffic in Germany:
  - Experts estimate this by 80% by 2025 (while the proportion rises on revenue and a performance of the street from 72% to 76%)
  ➔ increase of CO$_2$ emission apparently inevitable
3. GAMS

Traffic volume 2004

Traffic capacity 2004

Traffic volume 2025

Traffic capacity 2025

+80%
Required information:

- **CO₂-emissions per tkm**
  - today and '2025'
- For today it can not be determined, depending on several factors
  - Utilization (all transport modes)
  - Mix (train)
  - For inland waterway vessels, according to experts no simple answer possible

**CO₂-emissions per tkm depending on the average load factor**

![Graph showing CO₂-emissions per tkm for different transport modes and load factors.](image-url)
Positive: technological progress

Raising efficiency (commercial vehicles)

CO₂-emissions from road transport per tonne-kilometer (1991 = 100%)
3. GAMS

- **Not yet considered**
  - The shift from road to other modes tend induce a higher traffic volume (due to longer distances)
  - Not all transports can be relocated (short-range transport in particular) or it doesn´t make sense
  - Maybe resulting run-time differences that are necessarily considered (especially in the JIT / JIS supply)
  - The complete air traffic: Due to the high costs and CO₂-emissions per tkm, would be in breach of the speed advantage to reduce air freight to 0 the result

- **In addition, two flow restrictions adopted in the calculation:**
  - Capacity barge: Max 300% of today's traffic performance because the restricted network can not be extended indefinitely
  - Rail capacity: Max 250% of today's traffic volumes due to limited infrastructure, the increase in 2025 is not infinite
<table>
<thead>
<tr>
<th>mode of transport</th>
<th>2004</th>
<th></th>
<th></th>
<th>2025</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mio. tkm(^1)</td>
<td>g/CO(_2) per tkm(^2)</td>
<td>CO(_2) [Mio. t.]</td>
<td>Cost per tkm [€](^3)</td>
<td>Total cost [Mio. €]</td>
<td>Mio. tkm(^4)</td>
</tr>
<tr>
<td>Road transport</td>
<td>392.600</td>
<td>77,5</td>
<td>30.427</td>
<td>0,05</td>
<td>19.630</td>
<td>706.680</td>
</tr>
<tr>
<td>Railway</td>
<td>91.921</td>
<td>68,5</td>
<td>6.297</td>
<td>0,055</td>
<td>5.056</td>
<td>165.458</td>
</tr>
<tr>
<td>IWT (Inland waterways)</td>
<td>63.667</td>
<td>40,5</td>
<td>2.579</td>
<td>0,035</td>
<td>2.228</td>
<td>114.601</td>
</tr>
</tbody>
</table>

\(^1\) source: Federal Statistical Office
\(^2\) average to the VDA
\(^3\) own estimate
\(^4\) +80% base year 2003, projection: BMVBS and ifmo
\(^5\) The VDA assumes a CO\(_2\) reduction of almost 30% per tkm for road transport, this value was transferred to the other modes
\(^6\) Adopted from 2004. Due to the scarcity of fossil fuels is expected by 2025, an increase that has to be included, adjusted for inflation. In addition, OPEC expects in their study, Oil outlook to 2025. With a constantly rising world oil demand by nearly 50%, which would have combined with the finiteness of a still incalculable price explosion that follows
sets
i Verkehrsträger / Strasse, Schiene, Schiff / ;

parameters
a(i) Kapazität der VT i im Jahr 2025 in Mio. tkm
/ Strasse 999999, Schiene 229802.5, Schiff 191001 /
b(i) Gramm CO2-Emission je tkm
/ Strasse 55, Schiene 48.6, Schiff 28.8 /
c(i) Kosten je tkm in €
/ Strasse 0.05, Schiene 0.055, Schiff 0.035 / ;

variables
X tkm je VT
Y CO2-Ausstoss
Z Gesamtkosten ;

positive variable x ;

equations
Costs Gesamtkosten
Co2emi CO2-Emission ermitteln
Co2lim CO2-Limit
Demand Bedarf an Transportleistung
Demmax Bedarfsobergrenze ;
costs .. z =e= sum((i), x*c(i)) ;
co2emi .. y =e= sum((i), x*b(i)) ;
co2lim .. y =l= 23581 ;
demand .. x =e= sum((i), a(i)) ;
demmax .. x =e= 986738 ;

model transport /all/ ;
solve transport using lp minimizing z ;
display x.l, x.m ;
4. Conclusion

- Vizualized restrictions
4. Conclusion

- Result with decimal places
  ➔ absolute objectivity and accuracy?
- Based on assumptions / estimates not given here!
  - Theoretical possibility of calculating the Minimal cost combination,
  - taking into account the carrying capacity of transport modes
  - and the maximum agreed CO$_2$-emissions
- This argumentation aids for infrastructure projects (feasible)
  - Iron Rhine (rail link to the Port of Duisburg port of Antwerp)
  - Trans-European Networks (Trans-European Networks; short TEN)
4. Outlook

- Next, the main factors influencing the calculation have to be identified
  - A possibility is by survey
  - And ranking by experts using, for example, AHP

- Then the GAMS has to be gradually expanded to complement factors, until the increase of complexity by adding additional factors increases no longer significant the gain of accuracy.
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Thank you for your keen interest in my presentation

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