MARGINAL COST PRICING

TUOMO SUVANTO
ECMT Workshop on Rail Infrastructure Charges
Rome 9.7.2004
STRUCTURE OF THE PRESENTATION

• WHY DO WE NEED MARGINAL COSTS?

• ECONOMETRIC APPROACH TO DEFINE THE MARGINAL COSTS OF USE OF THE RAIL INFRASTRUCTURE

• MARGINAL COSTS IN FINLAND

• AN ALTERNATIVE FOR ECONOMETRIC APPROACH

• FINNISH TRACK CHARGING SYSTEM
MARGINAL COSTS  (1/4)

• THE TRACK CHARGES ARE DETERMINED BY THE DIRECTIVE 2001/14

• ONE MANDATORY CHARGE AND FIVE OPTIONAL CHARGES
MARGINAL COSTS (2/4)

- THE ONLY MANDATORY CHARGE IS THE CHARGE FOR THE MINIMUM ACCESS PACKAGE AND TRACK ACCESS TO SERVICE FACILITIES (ARTICLE 7)

- “IT MUST BE SET AT THE COST THAT IS DIRECTLY INCURRED AS A RESULT OF OPERATING THE TRAIN SERVICE”

= THE MARGINAL COST OF THE USE OF EXISTING INFRASTRUCTURE.
OPTIONAL CHARGES

1. ENVIRONMENTAL CHARGES (Article 7)

2. SCARCITY CHARGE (Article 7)

3. MARK-UPS (Article 8)

4. INVESTMENT CHARGE (Article 8)

5. RESERVATION CHARGE (Article 12)
MARGINAL COSTS (3/4)

- MARGINAL COST IS THE CHANGE IN TOTAL COSTS OF PRODUCTION WHICH RESULTS WHEN OUTPUT IS VARIED BY ONE UNIT

- MARGINAL COSTS ARE THOSE CAUSED BY ONE ADDITIONAL TRAIN ENTERING THE NETWORK

- MATHEMATICALLY MARGINAL COSTS ARE THE FIRST DERIVATE OF A TOTAL COST FUNCTION TO THIS ADDITIONAL TRAFFIC UNIT
MARGINAL COSTS (4/4)

• THE COSTS WHICH VARY DIRECTLY WITH USE ARE RELEVANT FOR ESTIMATING THE SHORT RUN MARGINAL COSTS OF INFRASTRUCTURE USE

• THE FIXED COSTS ARE IN THE SHORT RUN REGARDED AS SUNK COSTS. FROM AN EFFICIENCY POINT OF VIEW, THESE COSTS ARE NOT RELEVANT FOR PRICING

• THE INFRASTRUCTURE COSTS MUST BE ALLOCATED BETWEEN FIXED AND VARIABLE COSTS
ECONOMETRIC APPROACH (1/4)

• AN ECONOMETRIC APPROACH ESTIMATES A TOTAL COST FUNCTION AND TAKES THE FIRST DERIVATE OF TOTAL COST WITH RESPECT TO GROSS TONNE KILOMETRES TO DERIVE THE MARGINAL COST

• FIRST STUDY WAS MADE BY JOHANSSON & NILSSON 1998 IN SWEDEN

• ECONOMETRIC APPROACH HAS BEEN USED IN AUSTRIA, FINLAND AND SWEDEN
ECONOMETRIC APPROACH (2/4)

• STEP 1.
  DEFINATION OF THOSE COST ELEMENTS WHICH ARE RELEVANT FOR SHORT RUN MARGINAL COSTS (CATEGORISATION TO FIXED AND VARIABLE COSTS)

• STEP 2.
  SPECIFICATION OF THE VARIABLES OF THE COST FUNCTION AND COLLECTION OF COST AND USAGE DATA FOR DIFFERENT TRACK UNITS

\[ C_{it} = g(Y_{it}, U_{it}, z_{it}, \epsilon_{it}) \]
ECONOMETRIC APPROACH (3/4)

• STEP 3.
ESTIMATION OF THE COST FUNCTION IN ORDER TO DETECT FUNCTIONAL RELATIONSHIP BETWEEN COSTS, INFRASTRUCTURE CHARACTERISTICS AND USE OF INFRASTRUCTURE

• STEP 4.
DERIVATION OF THE ESTIMATED COST FUNCTION AND CALCULATION OF MARGINAL COST IN RELATION TO GROSS TONNE KILOMETRES (GTKM)
ECONOMETRIC APPROACH (4/4)

ADVANTAGE:

- Follows the theoretical principle of marginal cost pricing

DISADVANTAGE:

- Requires good and detailed data
THE FINNISH RAIL NETWORK AND TRAFFIC 2002

- TOTAL LENGTH OF RAILWAY LINES 5 850 KM
- TOTAL TRACK LENGTH INCLUDING SIDINGS 8 736 KM
- ELECTRIFIED LINES 2400 KM

- PASSENGERS CARRIED 54.7 MILLION
- PASSENGER KILOMETERS 3,405 BILLION
- RAILWAYS MARKET SHARE IN PASSENGER TRAFFIC 4.5%

- TONNES CARRIED 40.6 MILLION
- TONNE-KILOMETERS 10.1 BILLION
- RAILWAYS MARKET SHARE IN FREIGHT TRAFFIC 24%
MARGINAL COSTS OF USING THE RAIL INFRASTRUCTURE IN FINLAND

• TWO STUDIES:

IDSTRÖM 2001
DATA FROM YEARS 1997-1999

IDSTRÖM & TERVONEN 2004

www.rhk.fi

--- RHK in English

--- Research and Publications
STEP 1. CATEGORISATION OF THE INFRASTRUCTURE COSTS (1/3)

• CATEGORISATION OF THE INFRASTRUCTURE COSTS TO FIXED AND VARIABLE COSTS IS BASED ON THE RECOMMENDATIONS MADE BY THE EXPERT ADVISORS TO THE HIGH LEVEL GROUP ON INFRASTRUCTURE CHARGING

• WORKING GROUP 1 REPORT 28.4.1999: ”CALCULATING TRANSPORT INFRASTRUCTURE COSTS”
<table>
<thead>
<tr>
<th>Cost category</th>
<th>Fixed costs</th>
<th>Variable costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land purchase</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Construction of new lines</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Enlargement of existing lines</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Replacement investments</td>
<td>partly</td>
<td>partly</td>
</tr>
<tr>
<td>- major repairs</td>
<td>partly</td>
<td>partly</td>
</tr>
<tr>
<td>- renewals</td>
<td>partly</td>
<td>partly</td>
</tr>
<tr>
<td>Construction maintenance</td>
<td>partly</td>
<td>partly</td>
</tr>
<tr>
<td>- minor repairs</td>
<td>partly</td>
<td>partly</td>
</tr>
<tr>
<td>- ballast cleaning</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Ongoing maintenance and operation</td>
<td>yes</td>
<td>partly</td>
</tr>
<tr>
<td>- winter maintenance</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>- cleaning, cutting</td>
<td>yes</td>
<td>partly</td>
</tr>
<tr>
<td>- check of facility conditions</td>
<td>yes</td>
<td>partly</td>
</tr>
<tr>
<td>- servicing for safety reasons</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>- operation of signalling etc.</td>
<td>mainly not</td>
<td>partly</td>
</tr>
<tr>
<td>- traction current</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Administration</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>- overhead</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>- police</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>- time tabling</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>
## STEP 1. CATEGORISATION OF THE INFRASTRUCTURE COSTS (3/3)

<table>
<thead>
<tr>
<th>MILLION €</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FIXED COSTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- New lines and enlargement investments, land purchase</td>
<td>81</td>
<td>59</td>
<td>87</td>
</tr>
<tr>
<td>- Traffic control</td>
<td>35</td>
<td>37</td>
<td>38</td>
</tr>
<tr>
<td>- Administration, overheads</td>
<td>21</td>
<td>23</td>
<td>28</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>137</td>
<td>119</td>
<td>153</td>
</tr>
<tr>
<td><strong>Share of total costs</strong></td>
<td>34 %</td>
<td>31 %</td>
<td>37 %</td>
</tr>
<tr>
<td><strong>VARIABLE COSTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Maintenance</td>
<td>112</td>
<td>121</td>
<td>130</td>
</tr>
<tr>
<td>- Replacement investments</td>
<td>152</td>
<td>143</td>
<td>135</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>264</td>
<td>264</td>
<td>265</td>
</tr>
<tr>
<td><strong>Share of total cost</strong></td>
<td>66 %</td>
<td>69 %</td>
<td>63 %</td>
</tr>
<tr>
<td><strong>TOTAL COSTS</strong></td>
<td>401</td>
<td>383</td>
<td>418</td>
</tr>
</tbody>
</table>
STEP 2. DATA COLLECTION AND ALLOCATION TO TRACK UNITS (1/2)

• THE RAIL NETWORK WAS DIVIDED TO 93 TRACK SECTIONS

• DATA PROBLEMS:
  - LACK OF TRAFFIC OR COST DATA FOR CERTAIN TRACK UNITS
  - SOME OF THE COSTS COULD NOT BE ALLOCATED TO TRACK UNITS
  - NO TRAFFIC DATA (GROSS TONNES) AVAILABLE FOR MARSHALLING YARDS

• THUS, A PART OF THE COSTS HAD TO BE LEFT OUT OF THE ESTIMATION
STEP 2. DATA COLLECTION AND ALLOCATION TO TRACK UNITS (2/2)


- COSTS FOR MARSHALLING YARDS WERE NOT INCLUDED IN THE COST FUNCTION

- THUS, THE CALCULATED MARGINAL COSTS REPRESENT ONLY MARGINAL COSTS FOR USING RAILWAY LINES IN FINLAND
STEP 3. ESTIMATION OF THE COST FUNCTION

• ONE OBJECTIVE OF THE STUDY WAS TO FIND OUT THE IMPACT OF REPLACEMENT INVESTMENTS ON MARGINAL COSTS

• TWO COST FUNCTIONS WERE ESTIMATED:

- A COST FUNCTION WITH ALL VARIABLE COSTS (MAINTENANCE + REPLACEMENTS)

- A COST FUNCTION WITH ONLY MAINTENANCE COSTS
STEP 3. ESTIMATION OF THE COST FUNCTION, RESULTS (1/3)

- ALL VARIABLE COSTS INCLUDED IN THE COST FUNCTION

PARAMETER ESTIMATES (COEFFICIENTS)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>CONSTANT</th>
<th>DUMMY</th>
<th>TRACK LENGTH</th>
<th>GROSS TONNES</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>4,480</td>
<td>1,138</td>
<td>0,896</td>
<td>0,290</td>
<td>0,51</td>
</tr>
<tr>
<td>2001</td>
<td>4,5932</td>
<td>1,1185</td>
<td>0,9583</td>
<td>0,2967</td>
<td>0,56</td>
</tr>
<tr>
<td>2002</td>
<td>4,5874</td>
<td>0,9525</td>
<td>0,960</td>
<td>0,2714</td>
<td>0,51</td>
</tr>
</tbody>
</table>

DUMMY = FOR REPLACEMENT INVESTMENTS
STEP 3. ESTIMATION OF THE COST FUNCTION, RESULTS (2/3)

- ONLY MAINTENANCE COSTS INCLUDED IN THE COST FUNCTION

PARAMETER ESTIMATES (COEFFICIENTS)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>CONSTANT</th>
<th>DUMMY</th>
<th>TRACK LENGTH</th>
<th>GROSS TONNES</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>6,878</td>
<td>0,611</td>
<td>0,691</td>
<td>0,132</td>
<td>0,72</td>
</tr>
<tr>
<td>2001</td>
<td>6,132</td>
<td>0,581</td>
<td>0,983</td>
<td>0,155</td>
<td>0,73</td>
</tr>
<tr>
<td>2002</td>
<td>6,834</td>
<td>0,472</td>
<td>0,590</td>
<td>0,174</td>
<td>0,68</td>
</tr>
</tbody>
</table>

DUMMY = FOR MAINTENANCE LEVEL
STEP 3. ESTIMATION OF THE COST FUNCTION, RESULTS (3/3)

- THE ESTIMATED COEFFICIENT CAN BE INTERPRETED AS AN ELASTICITY

- ESTIMATED COEFFICIENT FOR GROSS TONNES 0.27 – 0.29 (REPLACEMENT INVESTMENTS + MAINTENANCE COSTS INCLUDED)

- ESTIMATED COEFFICIENT FOR GROSS TONNES 0.13 – 0.17 (ONLY MAINTENANCE COSTS INCLUDED)

- IF TRAFFIC LEVEL (GROSS TONNES) INCREASES BY 10 %, VARIABLE COSTS WILL INCREASE BY 2.7 – 2.9 % (BY 1.3 – 1.7 % FOR MAINTENANCE COSTS)
STEP 4. CALCULATION OF MARGINAL COST (1/5)

- AVERAGE MARGINAL COSTS IN 2000-2002, CENTS/GROSS TKM

<table>
<thead>
<tr>
<th>YEAR</th>
<th>ALL VARIABLE COSTS INCLUDED</th>
<th>ONLY MAINTENANCE COSTS INCLUDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>0,0872</td>
<td>0,0179</td>
</tr>
<tr>
<td>2001</td>
<td>0,0840</td>
<td>0,02313</td>
</tr>
<tr>
<td>2002</td>
<td>0,0765</td>
<td>0,02458</td>
</tr>
</tbody>
</table>

- SWEDEN 0,0129
- AUSTRIA 0,055
STEP 4. CALCULATION OF MARGINAL COST (2/5)

• SMALLEST MARGINAL COSTS cents/gtkm
  Track section
  • Uimaharju-Nurmes 0.0186
  • Ylivieska-Tuomioja 0.0214
  • Juurikorpi-Hamina 0.0231

• LARGEST MARGINAL COSTS cents/gtkm
  Track section
  • Saarijärvi-Haapajärvi 1.3369
  • Kankaanpää-Parkano 4.2251
  • Parkano-Aittoneva 10.2744

• WEIGHTED AVERAGE IS USED FOR PRICING
STEP 4. CALCULATION OF MARGINAL COST (3/5)

- Maintenance costs + replacement costs
- Maintenance costs
STEP 4. CALCULATION OF MARGINAL COSTS (4/5)

Marginal costs 1997-2002 in nominal prices and six years weighted average in prices of 2002
STEP 4. CALCULATION OF MARGINAL COSTS (4/5)

• WHY MARGINAL COSTS WERE HIGHER IN FINLAND IN 1997-1999 THAN IN 2000-2001?

  . THE MOST IMPORTANT REASON IS THE DROP IN REPLACEMENT INVESTMENT BUDGETS IN 2000-2002

  . DATA FOR YEARS 1997-1999 WAS BETTER THAN FOR YEARS 2000-2002
RESULTS

• MARGINAL COSTS WERE 15.6 - 18.9 % OF VARIABLE COSTS IN 1997- 2002

• ”A RULE OF THUMB”: MARGINAL COSTS ARE 20 % OF VARIABLE COSTS OF RAILWAY LINES IN FINLAND (15 % OF MAINTENANCE COSTS)
AN ALTERNATIVE FOR ECONOMETRIC APPROACH: A PRAGMATIC APPROACH

• A PRAGMATIC APPROACH CAN BE USED IF THE AVAILABLE COST DATA IS NOT SUFFICIENT FOR ECONOMETRIC ESTIMATION

• STEP 1. ALLOCATE INFRASTRUCTURE COSTS TO FIXED AND VARIABLE COSTS

• STEP 2. DECIDE WHICH PART OF THE VARIABLE COSTS ARE MARGINAL (E.G. 20 %)

• STEP 3. COUNT MARGINAL COSTS

(VARIABLE COSTS * 0,2)/GROSS TKM

THE RESULT IS AN AVERAGE MARGINAL COST PER GROSS TKM FOR THE WHOLE RAILWAY NETWORK
THE FINNISH TRACK CHARGING SYSTEM (1/4)

• A BASIC CHARGE (MARGINAL COSTS)
  FREIGHT TRAFFIC 0,12227 CENTS/GTKM
  PASSENGER TRAFFIC 0,1189 CENTS/GTKM

• A RAIL TAX (MARK UP + ENVIRONMENTAL CHARGE)

• PASSENGER TRAFFIC 0,01 CENTS/GTKM
  (ENVIRONMENTAL CHARGE)

• FREIGHT TRAFFIC
  - ELECTRIC-POWERED 0,05 CENTS/GTKM
    (MARK-UP 0,04 + ENV. 0,01)
  - DIESEL-POWERED 0,1 CENTS/GTKM
    (MARK-UP 0,04 + ENV. 0,06)
INVESTMENT CHARGE

A DECISION MADE TO APPLY AN INVESTMENT CHARGE FOR A NEW LINE KERAVA-LAHTI (IN OPERATION 2006) (TOTAL 4 MILJ. €/YEAR FOR 15 YEARS)
THE FINNISH TRACK CHARGING SYSTEM (3/4)

- YEAR 2003

<table>
<thead>
<tr>
<th>BASIC CHARGE</th>
<th>41,4 MILLION € (72 %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSENGER TRAFFIC</td>
<td>13,3</td>
</tr>
<tr>
<td>FREIGHT TRAFFIC</td>
<td>28,1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RAIL TAX</th>
<th>16,4 MILLION € (28 %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSENGER TRAFFIC</td>
<td>1,1</td>
</tr>
<tr>
<td>FREIGHT TRAFFIC</td>
<td></td>
</tr>
<tr>
<td>- ELECTRIC POWERED</td>
<td>7,7</td>
</tr>
<tr>
<td>- DIESEL POWERED</td>
<td>7,5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TOTAL</th>
<th>57,7 MILLION € (100 %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSENGER TRAFFIC</td>
<td>14,4 (25 %)</td>
</tr>
<tr>
<td>FREIGHT TRAFFIC</td>
<td>43,3 (75 %)</td>
</tr>
</tbody>
</table>
THE FINNISH TRACK CHARGING SYSTEM (4/4)

THE TRACK CHARGES COVER ABOUT

14 % OF THE TOTAL RAIL INFRASTRUCTURE COSTS

22 % OF TOTAL VARIABLE COSTS

44 % OF TOTAL MAINTENANCE COSTS