Validation Procedure and Quality Management for Transport Demand Modeling

Research Project QUALIVERMO
Funded by bmvit Vienna and ASFINAG

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Fachbeirat VKM AT-SK & AT-HU
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Goal of Project

• Development quality management system for practical use

• Validation procedure of transport demand model and its results

• Development of validation guidelines
The problem? (1)

- Much evidence: application of transport modeling (TDM) often with low quality

Examples:
- Before-and-after analysis of European Investment Bank
- Comparison of modeling results for Vienna Region
- Analysis of mega projects and their risks
The problem? (2)

Result of three TDM applications for the highway network in Vienna Region (prognoses of same target year and same framework condition)

Consultancy A
combined software
self-development
+ market software

33.400

Traffic volume of an average working day [ vehicles/24 hours]

Consultancy B
combined software
self-development
+ market software

45.000

Consultancy C
software available
on the market

88.400
The problem? (3)

27 railway investment projects
Reference: Flyvbjerg et.al. 2003

Mean value: -39 %
Reasons for unsatisfying quality of TDM results (1)

- Cost and time pressure on consultants by clients
- Pressure on client-friendly results (appraisal bias of project promoter and consultant)
- Unexpected development of external influence etc.
- Increasing complexity of model-software
  - no adequate training
  - no insight knowledge
  - no extensive software documentation
Reasons for unsatisfying quality of TDM results (2)

- Model application without adequate behavioral data and calibration
- Little willingness to disclose accuracy of results (e.g. confidence interval for traffic volume)
- Problem of matrix calibration by traffic counts of network-links

→ Need for standardized quality management!
Structure of presentation

- Methodical elements of quality management (QM) for TDM
- Selected topics of quality management
- Conclusion
Literature review

• A lot of papers addressing the problem
• Interesting suggestions

• Historical GEH-formular  
  (Geoffrey E. Harver 1970)

\[
GEH_i = \left( \frac{2x|V_{m,i} - V_{b,i}|}{V_{m,i} + V_{b,i}} \right)^{\frac{1}{2}}
\]

GEH<sub>i</sub>: Quality indicator of the count point i  
V<sub>m,i</sub>: Modeled traffic volume at the control count point i  
V<sub>b,i</sub>: Observed traffic volume at the control count point i

• No standardized validation procedure
Objectives of validation and quality procedure (1)

- To increase significance of TDM-results
- To raise awareness for the need of quality assurance
- To disclose the accuracy and uncertainty
- To avoid the use of black-box TDM
- To disclose the objectives of TDM-applications and quality needs
Objectives of validation and quality procedure (2)

To improve the transparency of
- the input data
- the TDM mechanism

To standardize
- the assessment of TDM-results
- the TDM-documentation

To make the TDM-software results comparable
Elements of standardized validation procedure (A)

(1) Documentation of application case
(2) Scoping of the application system
(3) Input data
(4) Disclosure of model mechanism of all steps (trip generation and attraction, origin, destination, mode, route, time of day choice)
Elements of standardized validation procedure (B)

(5) One-variable test of TDM-mechanism

(6) Plausibility checks with test cases

(7) Plausibility checks with back casting

(4) Plausibility checks with “spider” transport network diagram
Disclosure of TDM mechanism

- Documentation of the model mechanism
- Documentation of any manual intervention
- Documentation of the calibration
- Standardized presentation of the analysis case and cases with measures
Distinction between two types of model calibration

a) Calibration of the travel behaviour parameters
   → contribution to explanation the quality of TDM (documentation of R2 etc.)

b) Calibration without any contribution to explain the travel behavior (e.g. O-D matrix estimate procedure with traffic counts)
   → disclosure of effects by quality indicators
Steps of QM for Route Choice and Assignment (1) (Example)

- Documentation of the model mechanism, elasticity (e.g. VOT)

- Disclosure of the correction steps in qualitative and quantitative way (RMSE of difference between the observed and modeled traffic volumes)

- Explanatory quality of the calibration of route choice (e.g. ratio between predicted and observed routes)
Steps of QM for Route Choice and Assignment (2) (Example)

• Quality indicators for differences between the observed and modeled traffic volumes for selected cut lines
  – RMSE (rout-mean-square error)
  – distribution of differences

• Disclosure of results: comparison of the mileage, total travel time of all scenarios and subdivided into internal, origin-, destination traffic etc.

• Confidence interval of traffic volume of network links
Quality indicator (A): Percentage root-mean-square error

\[ RMSE = 100 \times \left[ \frac{1}{n} \cdot \sum \left( \frac{V_{a,i} - V_{b,i}}{V_{b,i}} \right)^2 \right]^{0.5} \]

- \( n \): Sample size
- \( V_{a,i}, V_{b,i} \): Set of compared variables

Application:
- Comparison of the modeled and observed variables (e.g. transport volume/day)
- Disclosure of changes of the input variables for different scenarios (e.g. population, travel time)
- Documentation of the confidence interval (e.g. transport volume/day)
Quality indicator (B): Relativ and absolute confidence interval for modeled transport volume of transport network

\[ RCI_{VSK} = 1,96 \times RMSE_{VSK} \quad \text{[in % of the traffic volume]} \]

\[ ACI_{VSK} = 1,96 \times ARMSE_{VSK} \quad \text{[unit of the traffic volume/unit of time]} \]

→ Rules for selection of traffic count points
  – Screen-, cut- and cordon-line
  – representative sample size of transport volume classes
Check with traffic and P.t. User Counts
(Screen-, cut- and cordon-line)
Relative confidence interval for the daily car traffic volume in the Vienna Region 2003

Level of significance 95 %
Absolute confidence interval for the daily car traffic volume in the Vienna Region 2003

Level of significance 95 %
Relative confidence interval for the daily car traffic volume in Austria 2005

Level of significance 95 %
Explanatory quality indicator of TDM for modeled transport volume of the network (weighted and unweighted version)

\[
EQI = \frac{S_b^2 - S_d^2}{S_b^2} = 1 - \frac{S_d^2}{S_b^2}
\]

\[
S_d = \left[ \frac{\sum (b,i \cdot V_{m,i})^2}{n-1} \right]^{\frac{1}{2}}
\]

Standard deviation of modeled and observed transport volume

\[
S_b = \left[ \frac{\sum (b,i \cdot MW_b)^2}{n-1} \right]^{\frac{1}{2}}
\]

Standard deviation of observed and average observed transport volume

\[
MW_b = \frac{\sum V_{b,i}}{n}
\]

Mean volume of observed transport volume
Result for the unweighted $\text{EQI}_u$ and the weighted $\text{EQI}_g$ for three different transport demand models of Eastern Austria

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{EQI}_u$</td>
<td>0.988</td>
<td>0.884</td>
<td>0.883</td>
</tr>
<tr>
<td>$\text{EQI}_g$</td>
<td>0.953</td>
<td>0.936</td>
<td>0.945</td>
</tr>
</tbody>
</table>

$\text{EQI}_u$: unweighted
$\text{EQI}_g$: weighted by the length of the network link
Quality management process of TDM with online peer-reviewing

Client
Local Authority

Invitation to tender
Defined quality standards
Transport model software is made available

Transport Consultancy A
Development of transport model XY by using software Z
step 1
step 2
step 3
etc.

Transport Consultancy D
Peer-reviewing process
peer-reviewing AS1
peer-reviewing AS2
peer-reviewing AS3
etc.

End-product
Quality-controlled transport model XY
Organizational structure to avoid TDM-monopoly

Client
Local Authority

Invitation to tender

Transport Consultancy A
Consulting contract covering several years (e.g. 5 years)
- Development of transport model XY by using software Z
- Development of the transport model with peer-review process
- Calibration
- Maintenance
- Administration of model and data
- Data updating
- Filing
- Quality control etc.

Delivery of data and data reception

Transport Consultancy B
- Conducting a specific transport study I
- Use of the transport model XY with software Z

Transport Consultancy C
- Conducting a specific transport study II
- Use of the transport model XY with software Z

Invitation to tender

etc.
Procedure for development of guidelines

• Cooperation of research associations of 3 countries A, CH, D

• 2 workshops

• Revision of draft

• Final workshop: September 2012

• Test for VKM AT-SK and AT-HU
Conclusion

• Quality management for TDM possible and necessary

• New organizational structure of TDM-process

• Implementation of quality indicators in TDM-software

• Individual definition of desired quality level for each application (check list)
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