Bevorzugter Zitierstil für diesen Vortrag

Axhausen, K.W. (2008) What does similarity measure?, Invitational *Workshop on Discrete Choice Models*, EPF Lausanne, Lausanne, August 2008.

What does similarity measure?

KW Axhausen

IVT
ETH
Zürich

August 2008

Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Addressing the IIA property of the MNL/1

How similar are the ε_{jq} ?

$$\Omega_{ij} = \sigma^2 \begin{bmatrix} 1 & 0 & \dots & 0 \\ 0 & 1 & \dots & 0 \\ \vdots & & & \\ 0 & 0 & \dots & 1 \end{bmatrix}$$

$$\Omega_{ij} = \begin{bmatrix} \sigma^2{}_{11} & -\sigma^2{}_{21} & \cdots & -\sigma^2{}_{n1} \\ \sigma^2{}_{21} & \sigma^2{}_{22} & \cdots & -\sigma^2{}_{n2} \\ \vdots & & & \\ \sigma^2{}_{n1} & \sigma^2{}_{n2} & \cdots & \sigma^2{}_{nn} \end{bmatrix}$$

Identical and independent or variabel and correlated

Addressing the IIA property of the MNL/2

Idea:

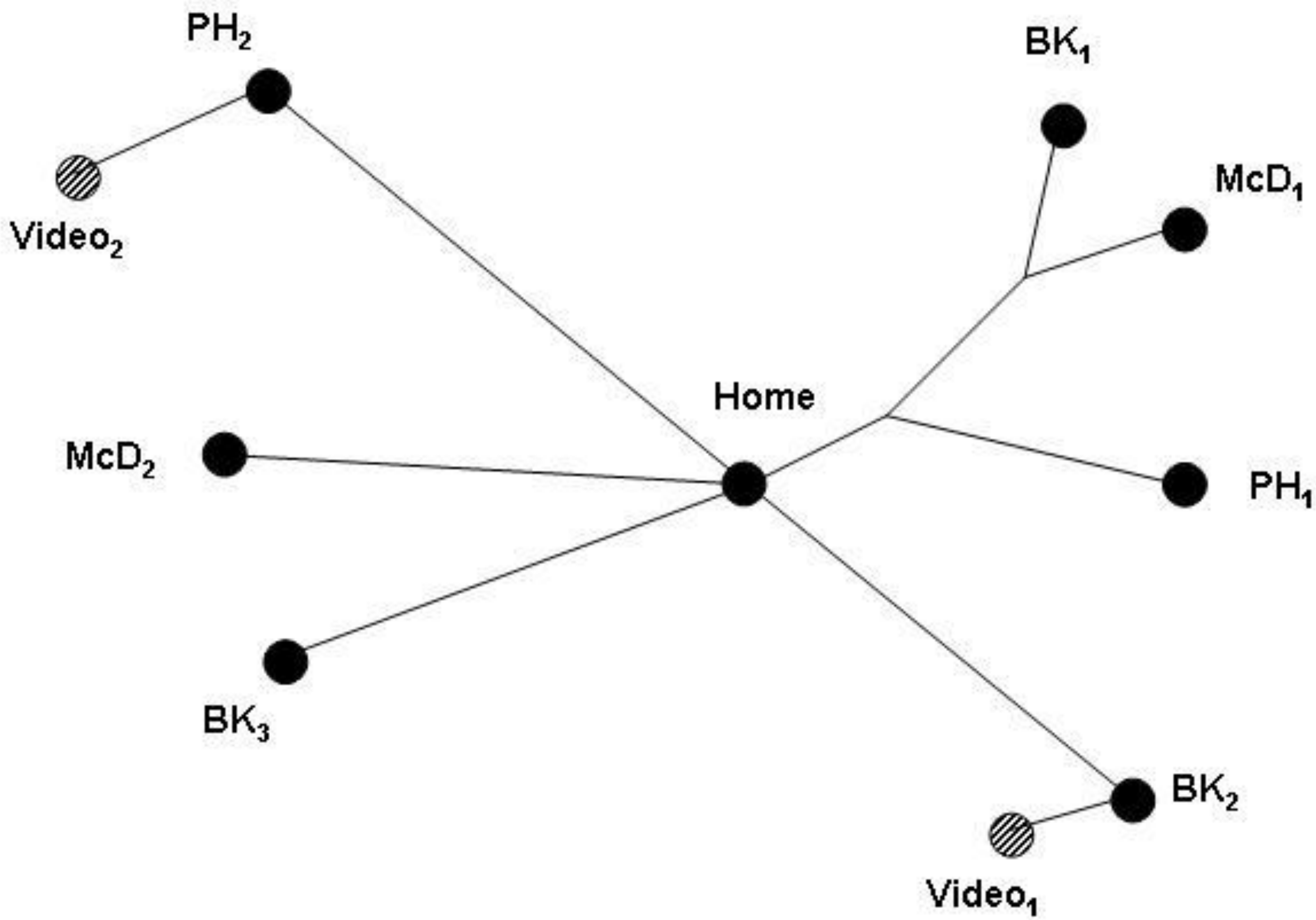
Expand V_i with a penalty term proportional to the average *similarity* with the other alternatives

$$U_{in} = V_{in}^{'} - \vartheta_{Cin} + \varepsilon_{in}$$

But, how to measure it

- Temporal closeness of the time-space paths
- Spatial overlap of the time-space paths
- Overlap of level and style of pricing
- Control of time table and company
- Comfort
- Brand of the service
- Cost and quality of the service at the destinaton
- Kind and density of other services surounding the destination

Example situation



Mechanisms

- Visibility of the alternative

Only visibility ?

Oberhausen (Wekeck/Friedrich) (BC)	+/-
Montreal (Wekeck/Friedrich) (BC)	-/+
Zurich-based air travel (BC)	-/+
European air travel (Wekeck/Friedrich) (ln)	+/0
Cycling route choice (PS) (ln)	+/0

Other mechanisms ?

- Aggregation to form a generic alternative (and loss of visibility) (negative penalty)
- Aggregation in the time-space system (and joint incidence of breakdown and traffic volumes) (negative penalty)

- Aggregation to form a “super-alternative” (with a resulting larger capacity and chance for succesful activity performance) (positive penalty)
- “tip of iceberg effect” (and increase in visibility of the alternative) (positive penalty)

New formulation

One would want to test:

$$U_{in} = V_{in}^{'} + \beta_{\vartheta} \vartheta_{Cin} + \varepsilon_{in}$$

New formulation

Possible implementation:

- Similarity in attributes
- Visibility among alternatives

- Closeness (and aggregation) in time-space system

- Regret over a less-then-optimal choice (relative position)
- Rank (via tip-of-iceberg) (“Winner takes all”)

Route choice

- C-Logit (route overlap)
- PS-Logit (route overlap)
- Wekeck/Friedrich (schedule overlap, fare and travel time similarity)

Location choice

- Similarity in attributes (Batsell, 1981; Meyer and Eagle, 1982; Borgers and Timmermans, 1987)
- Attractivity of the vicinity (Kitamura, 1988)
- Dominance/rank (Pagliara et al., 2006)

Dominanz

With

$$R_{ij} = \prod_{\forall k} \left[\max(0, X_{ki} - X_{kj}) = 0 \right]$$

$$R_i = \sum_{\forall j \in J} R_{ij}$$

Location choice: Validity of assumptions

The availability of an alternative is a-priori unknown, which implies:

- Available capacity will be overestimated
- Overly positive assessment of the generalised costs on the way to a location

Location choice: Possibility of correction

- Iterative estimation (de Palma, Picard and Waddell, 2008)
- Penalty (Martinez, 2007)

Other implementations

- Field effects
- Prospect theory
- Regret
- Rank/dominance

Field effect

With:

$$P(y_{ki}) \sim \beta X_{ki} + W_y \, \bar{y}_{\forall j \neq ì} + W_x \, \bar{X}_{\forall j \neq ì} + \ldots \varepsilon_{ki}$$

$$with$$

$$\begin{aligned} y_i &= \textit{Alternative k chosen by person i} \\ X_i &= \textit{Attributes of alternative k} \\ W &= \textit{weight matrix} \end{aligned}$$

Prospect theory

with

$$V_i = \sum_{\forall k} \alpha_k^+ f_k^+(\max(0, X_{ki} - X_{k0})) + \alpha_k^- f_k^-(\min(0, X_{ki} - X_{k0}))$$

where

α	Parameter; α^+ positive; α^- negative
f	funktion; f^+ concave; f^- convex
X_{ki}	Attribukte k of alternative I
	Alternative 0 is a reference alternative, generally the status-quo

Regret

with

$$R_{ij} = \sum_{\forall k} \max(0, \beta_k \; f(x_{kj} - x_{ki}))$$

$$R_i = \max_{\forall j}(R_{ij}) = \quad V_i$$

where

R_{ij}	"regret" for alternative i vis-à-vis alternative j
f()	Transformation, in Chorus *et al.* (2007) linear
k	Attribute k of Alternative I
β	Parameter

Swiss freight mode choice

- Data:
  - Recent telephone/CATI – SP experiments
  - Current choice is reference

- Alternatives:
  - Rail, Rail+Truck, Truck
- with
  - Distance, weight, value, type of movement
  - Cost
  - Travel time
  - Punctuality

Swiss freight mode choice

	Without panel-effect	With panel-effect
	LL adj. 2	LL adj. 2
MNL	-1182.93/0.470	-1047.88/0.529
CNL	-1181.69/0.469	-1026.85/0.537
Dominance	-1182.77/0.470	-1047.63/0.529
Batsell	-1166.74/0.476	-1030.16/0.536
Prospect theory	-1130.96/0.492	-975.97/0.560

Summary and outlook 1

- prospect theory”, “regret” and “dominance” are a continuum
- “similarity” and “capacity utilisation terms” are a continuum

- Can we unify the approaches ?
- Are they consistent with utility maximisation ?
- Are the elasticities correct ?

Summary and outlook 2

- Which mechanism is appropriate ? Can we give guidance ?

- Can we automate the iterative processes ?
- Can we identify the appropriate model form ?

Literature

Batsell, R. R. (1981l) A Multiattribute Extension ofthe Luce Model which Simultaneously Scales Utility and Substitutability, Working Paper, J. H. Jones Graduate School of Administration, Rice University.

Ben-Akiva, M. E. and M. Bierlaire (1999) Discrete choice methods and their applications to short-term travel decisions, in R. Hall (ed.) *Handbook of Transportation Science*, 5–34,Kluwer, Dordrecht.

Borgers, A.W. J. and H. J. P. Timmermans (1987) Choice model specification, substitution and spatial structure effects: A simulation experiment, *Regional Science and Urban Econimics*,**17**, 29–47.

Cascetta, E., A. Nuzzola, F. Russo and A. Vitetta (1996) A modified logit route choice model overcoming path overlapping problems: Specification and some calibration results for interurban networks, in J. B. Lesort (ed.) *Proceedings of the 13th International Symposium on Transportation and Traffic Theory*, 697–711, Pergamon, Oxford.

Cascetta, E., F. Paliara and K. W. Axhausen (2007) The use of dominance variables in choice set generation, in WCTRS (ed.) the *11th World Conference on Transportation Research*, Berkeley, Jun. 2007.

.

Literature

Cascetta, E. and A. Papola (2003) A joint mode-transit service choice model incorporating the effect of regional transport service timetables, *Transportation Research Part B*, **37** (7) 595–614.

Cascetta, E. and A. Papola (2005) Dominance among alternatives in random utility models: A general framework and an application to destination choice, in ETC (ed.) European Transport Conference, Strasbourg, Oct. 2005.

Dugundji, E. R. and J. L. Walker (2005) Discrete choice with social and spatial network interdepencies: An empirical example using mixed gev models with field and "panel" effects,in TRB (ed.) the *84th Annual Meeting of the Transportation Research Board*, Washington, D.C., Jan. 2005.

Fotheringham, A. S. (1988) Consumer store choice and choice set definition, *Marketing Science*, **7** (3) 299–310.

Frejinger, E. and M. Bierlaire (2007) Capturing correlation with subnetworks in route choice models, *Transportation Research Part B*, **41** (3) 363–378.

Friedrich, M., I. Hofsäss and S. Wekeck (2001) Timetable-based transit assignment using branch and bound techniques, *Transportation Research Record*, **1752**, 100–107.

Hoogendoorn-Lanser, S. and P. H. L. Bovy (2007) Modeling overlap in multi-modal route choice by inclusion of trip part specific path size factors, in TRB (ed.) the *86th Annual Meeting of the Transportation Research Board*, Washington, D.C., Jan. 2007.

Literature

Hoogendoorn-Lanser, S., R. van Nes and P. H. L. Bovy (2005) Path size and overlap in multimodal transport networks, in H. S. Mahmassani (ed.) *Flow, Dynamics and Human Interaction - Proceedings of the 16th International Symposium on Transportation and Traffic Theory*, 63–83, Elsevier, Oxford.

Kitamura, R. (1984) Incorporating trip chaining into analysis of destination choice, *Transportation Research Part B*, **18** (1) 67–81. Meyer, R. J. and T. C. Eagle (1982) Context-Induced Parameter Instability in a Disaggregate-Stochastic Model of Store Choice, *Journal of Marketing Research*, **19**, 62-71.

Martinez, F. (2007) The Constrained Multinomial Logit: a semi-compensatory choice model, paper to be presented at the 87th Annual Meeting of the Transportation Research Board, Washington, D.C., January 2008.

Meyer, R. J. and T. C. Eagle (1982) Context-Induced Parameter Instability in a Disaggregate-Stochastic Model of Store Choice, *Journal of Marketing Research*, **19**, 62-71

Literature

Ramming, M. S. (2002) Network knowledge and route choice, Ph.D. Thesis, Massachusetts Institute of Technology, Cambridge.

van Eggermond, M., N. Schüssler and K.W. Axhausen (2007) Accounting for similarities in air transport route choice, *Working Paper*, **456**, IVT, ETH Zurich, Zurich.

Vrtic, M. (2003) Simultanes Routen- und Verkehrsmittelwahlmodell, Ph.D. Thesis, Technical University Dresden, Dresden.

Weis, C. (2006) Routenwahl im ÖV, Master Thesis, IVT, ETH Zurich, Zurich.

Appendix

C-Logit 1 (Cascetta et al., 1996)

als:

$$CF_{in} = -\beta_0 \ln \sum_{a \in \Gamma_i} \frac{l_a}{L_i} N_{an}$$

Mit:

CF_{in}	Ähnlichkeit für Route i zwischen OD-Paar n
l_a	Länge von Strecke a auf Route i
L_i	Länge der Route i
N_{an}	Anzahl der Routen zwischen OD-Paar n, die Strecke a beinhalten
Γ_i	Satz der Strecken der Route i

C-Logit 2 (Cascetta et al., 1996)

als:

$$CF_{in} = \alpha \cdot \ln\left(1 + \sum_{\forall j \neq i, \varepsilon C_n} \left(\frac{L_{ij}}{L_i^{1/2} \cdot L_j^{1/2}}\right)^{\gamma}\right)$$

Mit:

CF_{in}	Ähnlichkeit für Route i zwischen OD-Paar n
L_{ij}	Gemeinsame “Länge” der Routen i und j
L_i	Länge der Route i
C_n	Satz der Routen zwischen OD-Paar n
α, γ	Parameter

Path Size Logit (Ben-Akiva and Bierlaire, 1999)

Wobei:

$$PS_{in} = \sum_{a \in \Gamma_i} \frac{l_a}{L_i} \frac{1}{\sum_{j \in C_n} \delta_{aj} \frac{L^*_{C_n}}{L_j}}$$

Mit:

PS_{in}	"path size"-Faktor für Route i zwischen OD-Paar n
l_a	Länge von Strecke a auf Route i
L_i	Länge der Route i
$L^*_{C_n}$	Länge der kürzesten Route zwischen OD-Paar n,
δ_{aj}	1, falls Strecke a zu Route j gehört; sonst 0
Γ_i	Satz der Strecken der Route i
C_n	Satz der Routen zwischen OD-Paar n

Eigenständigkeit einer Verbindung (Friedrich et al., 2000)

wobei

$$IND(c) = \frac{1}{\sum_{c' \in C} f_c(c')} = \frac{1}{1 + \sum_{c' \in C; c' \neq c} f_c(c')}$$

Mit Überlapppung des Zeitfensters $x_c(c')$, wahrgenommener Reisezeit $y_c(c')$ und Fahrpreis $z_c(c')$

$$f_c(c') = \left(1 - \frac{x_c(c')}{s_x}\right)^+ \cdot \left(1 - \gamma \cdot \min\left(1, \frac{|y_c(c')|}{s_y} + \frac{|z_c(c')|}{s_z}\right)\right)$$

s_x, s_y und s_z beschränken die Wirkung von $x_c(c')$, $y_c(c')$ und $z_c(c')$

s_y und s_z hängen vom Vorzeichen von $y_c(c')$ und $z_c(c')$ *ab*

γ Gewichtsfaktor

Eigenständigkeit einer Verbindung (Friedrich et al., 2000)

Überlappung des Zeitfensters:

$$x_c(c') = 0.5\left(\left|dt_c - dt_{c'}\right| + \left|at_c - at_{c'}\right|\right)$$

Nähe des Fahrpreises:

$$z_c(c') = c_c - c_{c'}$$

Mit

dt	Abfahrtszeit
at	Ankunftszeit
c	Fahrpreis

Eigenständigkeit einer Verbindung (Friedrich et al., 2000)

Nähe der empfundenen Reisezeit erz_c

$$y_c(c') = erz_c - erz_{c'}$$

$$erz_c = fz + \alpha \cdot uz + \beta \cdot u$$

Mit:

fz	Fahrzeit
uz	Umsteigezeit
u	Anzahl Umsteigen
α,β	Parameter; Bei Friedrich et al. jeweils gleich 2

Zielwahl: Ähnlichkeit 1

Batsell (1981):

$$\ln A_i = \frac{1}{J-1} \sum_{j \in J} \sum_{k \in K} \beta_k \left| X_{jk} - X_{ik} \right|$$

Mit

A_i	Ähnlichkeit von Ziel i
J	Satz aller betrachteten Ziele
K	Satz der Attribute
X	Wert des Attributs X
β_k	Parameter für Attribut k

Zielwahl: Ähnlichkeit 2

Meyer und Eagle (1982):

$$A_i = \left[\frac{1}{J-1} \sum_{j \in J} 0.5 \left| r_{ij} - 1 \right| \right]^{\beta}$$

Mit

A_i	Ähnlichkeit von Ziel i
J	Satz aller betrachteten Ziele
r_{ij}	Korrelation der Attribute der Ziele i und j
β	Parameter für Attribut k

Zielwahl: Ähnlichkeit 3

Borgers and Timmermans (1987):

$$A_i = \prod_{k \in K} \left[\frac{1}{J-1} \sum_{j \in J} \left| X_{ik} - X_{jk} \right| \right]^{\beta_k}$$

Mit

A_i	Ähnlichkeit von Ziel i
J	Satz aller betrachteten Ziele
K	Satz der Attribute
X_{ij}	Wert des Attributs k des Ziels i
β_k	Parameter für Attribut k

Umgebungsangebot und -qualität

Kitamura (1988) berücksichtigt die Erreichbarkeit vom Zielort aus

$$A_i = \ln \sum_{\forall i}^{c_{ij} \leq c_{ij,\max}} X_j \, e^{c_{ij}}$$

Mit

$c_{ij,max}$	Maximale generalisierte Kosten
X_j	Gelegenheiten am Ort j
c_{ij}	Generalisierte Kosten von I nach j, im einfachsten Fall: β(Reisezeit$_{ij}$)

Zielwahl mit Kapazitätsstrafen (Martinez, 2007)

Es sei:

$$V_i = \beta X_{ki} + \frac{1}{\mu} \ln \phi_{ki}(X_k) + \varepsilon_i$$

Mit

X	Eigenschaften k von Ziel i
Φ	Strafe mit:

$$\phi_{ki} = \prod_{\forall k} \phi_{ki}^{T} \phi_{ki}^{H}$$

Zielwahl mit Kapazitätsstrafen (Martinez, 2007)

Mit:

$$\phi_{ki}^{T} = 1 \Big/ 1 + e^{\omega_k (a_{ki} - X_{ki} + \rho_k)}$$

$$\phi_{ki}^{H} = 1 \Big/ 1 + e^{\omega_k (X_{ki} - b_{ki} + \rho_k)}$$

Und

a	Obere Grenze
b	Untere Grenze
ρ	Toleranz
ω	Parameter