Valuation of Time in Car and Public Transport: Stated Preferences Research and Pratical Use in Multimodal Modelling in the Czech Republic

The Results of Research and Development Project No.

CG721-045-190

External Cost of Transport 2011

Jan Kašík, NDCON, s.r.o.

Why We Need Multimodal Modelling

- To allocate resources for infrastructure development responsibly
- To be able to explain the extent of the compensation for public transport operation losses
- To judge, if the investment for public transport will be both environmentally and economic advantageous
- To judge the influence of the transport planning measures to modal split

Transport Planning

Transport problem definition

Traffic surveys

Analytic model

Definition of the measures

Traffic forecast

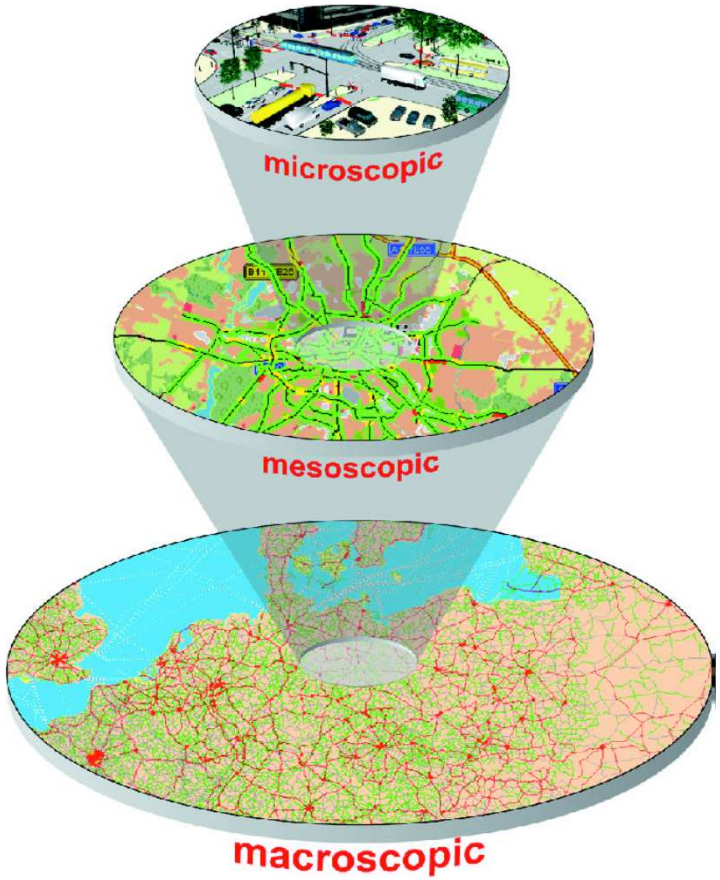
Measures testing

Measures evaluation

Chosen measures implementation

Model Structure

- Description of model area
- Model network creation
- Traffic survey data
- Area division and description
- Origin Destination trips
- Distribution (traffic relations)
- Modal choice
- Traffic allocation
- Calibration
- Direct use or detailed modelling



Surveys

- Traffic: questionnaires, stopping of the cars with question, counting

= revealed preferences

- Land use: land use planning, public transport, toll, traffic management

---

If out sufficient:

=stated preferences

(how would the respondents react)

Multimodal modelling

- Modal split after the distribution, before distribution or with the distribution ?
- Detached models – coordinated matrices – diferenciated modal split
- Multimodal forecast - matrix – distribution after the modal split, gravitation method, matrix of impedances (current model of Prague)
- Multimodal modelling including the traffic allocation (based on software capabilities) – new in the Czech Republic. New Prague model - New model of the Czech Republic – Transport Strategies for MoT 2013

Trends in multimodal modelling

- Modal split is becoming the most important part of modelling
- Direct demand modelling – trip generation, distribution modal split in one step
- The parameters for personal choice needed
- Types of modal split
  - Trip-end – before the distribution - USA the person decides – useful when PT is normally accessible and no congestions
  - Trip interchange – after the distribution –Europe – the journey parameters decide – useful only for persons with modal chice – matrix of car owners, price des not decide

  - Syntetic models – multimodal split, numeric logit function,
  - Direct demand models: - logit
  - Individual choice models: nested logit a polynominal logit

Why Multimodal Model ?

- For transport plans
- Substantial changes of the traffic offer
  - Toll
  - New PT lines
  - High Speed Railways
- Trends towards congestion in car transport
  - Slows down the car traffic growth
  - Necessary to implement to the models

Simple Calculations of Demand Changes - Elasticity

$$E_{DP} = \frac{Q_2 - Q_1}{(Q_2 + Q_1) : 2} : \frac{P_2 - P_1}{(P_2 + P_1) : 2}$$

UK surveys outputs

Fare, headways, accessibility and economy influence in PT	Elasticity to demand	PT Demand change if changes are = 20 %
Fare growth – short time	-0,2 : - 0,7	-4%: -14%
Fare growth – long time	-0,4 : -1,5	-8%: -30%
Time if PT service	0,2 : 0,8	4 : 16%
Medium income /GDP	-0,75	-15%

Parameters of Generalised Time – Key Parameters from the Surveys €/hour

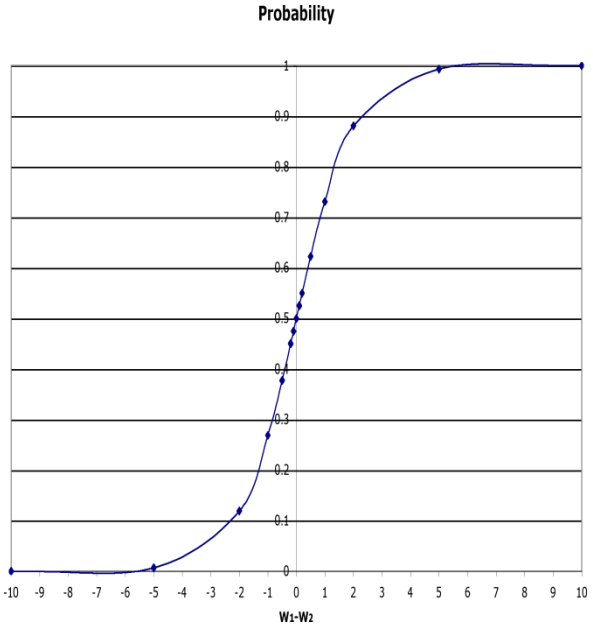
	UK	CZ
In vehicle time	5,7	0,9 - 1,3
Interchange	5 – 15	
Walking/Car	1,7 – 4,1	5,5
Walking/PT	1,5 – 3,1	3,3
Waiting for PT/Car	1,5 – 2,5	1,8

Možnosti softwaru	**CUBE VOYAGER**	**EMME/2**	**VISUM**
Time to the stop	Yes	Yes	Yes
Time from the stop	Yes	Yes	Yes
Interchange time	Yes	Yes	Yes
Stop waiting	Yes	Yes	Yes
Intercange waiting	Yes	Yes	Yes
In vehicle time	Yes	Yes	Yes
Fare	Yes	Yes	Yes
Interchnage fee	Yes	Yes	Yes
Initial fare	Yes	Yes	Yes
Length	Yes	Yes	No
Waing time	Yes	Yes	Yes
Fare strucutre	Complex	Simple	Simple

Modal Choice Models - Logit Model


- Multi-nominal logit model – average passenger will choose the trip with the lowest generalised costs
- Elasticity parameter μ (negative) – the expression of elasticity to change the mode related to cost
- $K_{HD\text{-}IAD}$ constant for practical balancing of the equitation – model system errors elimination
- Necessary for each relation A-B
- Nested logit for more complex choices

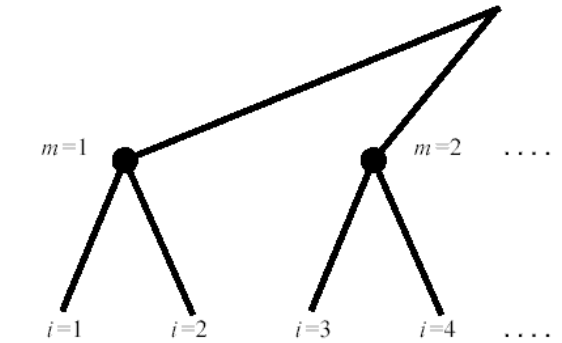
$$P_{ni} = \frac{e^{\mu V_{ni}}}{\sum_{nj \in J} e^{\mu V_{nj}}}$$



Nested Logit Model

- It is possible to use model in hierarchy way(nested logit model NL),
- Eg.: choice between car and PT first, then among the modes of PT (eg: bus/train)
- Eg.: To change the destination first, then the mode of transport

$$P_i = P_m P_{i|m}$$



$$P_i = \frac{e^{\frac{\mu V_i}{\mu_m}}}{\sum_{i' \in J} e^{\frac{\mu V_i'}{\mu_m}}}$$

$$I_m = ln \sum_{i' \in m} e^{\frac{\mu V_i'}{\mu_m}}$$

$$P_m = \frac{e^{\mu_m I_m}}{\sum_{m' \in M} e^{\mu_m I_m'}}$$

Stated Preferences Research

- The choice among hypothetic scenarios
- To find out possible direct impact of planed measures to transport behaviour
- Application eg. for the evaluation of improved transport demand quality
- The danger of false responses, misunderstandings

Karta č. 1			
Tram/Bus		**Varianta A**	**Varianta B**
	Docházkový čas celkem (minuty)	10	18
	Doba čekání na spoj (minuty)	2	10
	Doba jízdy (minuty)	25	10
	Jízdné (Kč)	20	26

Conclusions

- Multimodall model is a must for the planning of substantial changes of transport demand or the overload of road network
- Multimodal model is more complicated and expensive
  - Higher quality demands
  - Necessity to find out μ a K_{HD-IAD} for nearly each new model
- The elasticises can be applied for matrix construction
- There is general lack of survey data

SPR in Prague – the Goals

- **The test the method**
  - Cooperation of Jacobs from UK and Sofres Factum
  - Very complicated research with necessary cooperation of respondents
- **To define General cost model parameter values:**
  - In Vehicle Time (Car, PT)
  - Walk time weight (Car, PT)
  - Wait time weight (on stops)
  - „Penalties“ for interchange

Main SPR

- **The Choice between the Alternatives of the Same Mode with Different**
  - fare,
  - travel time,
  - walking time,
  - waiting time

Side SPR

- **The choice among Car, underground, bus/tram**
  - With different fare, travel time, walking time, waiting time
- **The choice among alternatives**
  - With different fare, travel time and necessity to change
- **The order of 9 alternatives definition**
  - Different fare, travel time, walking time

The Card Examples (2 of 9) – time evaluation

Karta č. 1

Tram/Bus	Varianta A	Varianta B
Docházkový čas celkem (minuty)	10	18
Doba čekání na spoj (minuty)	2	10
Doba jízdy (minuty)	25	10
Jízdné (Kč)	20	26

Karta č. 2

Tram/Bus	Varianta A	Varianta B
Docházkový čas celkem (minuty)	10	18
Doba čekání na spoj (minuty)	6	11
Doba jízdy (minuty)	20	12
Jízdné (Kč)	41	26

The Card Examples (2 of 9)– modal split evaluation

Karta č. 1

Výběr Auto - Tram/Bus		Varianta A	Varianta B
		Auto	Tram Bus
	Docházkový čas celkem (minuty)	2	12
	Doba čekání na spoj (minuty)		2
	Doba jízdy (minuty)	20	30
	Cena / Jízdné (Kč)	56	26

Karta č. 2

Výběr Auto - Tram/Bus		Varianta A	Varianta B
		Auto	Tram Bus
	Docházkový čas celkem (minuty)	2	12
	Doba čekání na spoj (minuty)		5
	Doba jízdy (minuty)	20	25
	Cena / Jízdné (Kč)	16	26

Gathering and Evaluation of Questionnaires

- 600 questionnaires
- ML Analyses (maximum probability)
- Software Biogeme tested ALOGIT
- Basic model of generelised costs created - standard multinominal logit

The Outputs of the Parameters of Generalised Costs

	Value (Kč/min.)			Weight to ride	
	Ride	Walk	Wait	Walk	Wait
Car	**0,65 *+/-0.3***	**3,58 *+/-0.7***	**-**	**5,53**	**-**
- Work	0,72				
- Other	0,48				
Underground	**0,28 *+/-0.13***	**0,86 *+/-0.16***	**0,72 *+/-0.19***	**3,05**	**2,57**
- Work	0,39				
- Other	0,1				
Bus	**0,33 *+/-0.12***	**1,1 *+/-0.15***	**0,59 *+/-0.17***	**3,37**	**1,79**
- Work	0,44				
- Other	0,18				
Tram	**0,3 *+/-0.12***	**1 *+/-0.15***	**0,72 *+/-0.16***	**3,37**	**2,41**
- Work	0,38				
- Other	0,14				

Model Choice Constant

Choice combinations		Car – U-ground	Car – Tram/Bus
Modal Constant (Kč/trip)	**Initial mode - Car**	18,04 +/- *15*	13,39 +/- *6.5*
	Initial mode - Underground/Tram/ Bus	-6,44	2,88

Main Results of Generalised Time Parameters

Value	Value	Walk weight	Change weight	Wait weight
Unit value car(Kč/min)	0.65	5.5		-
- Work	0,72			
- Other	0,48			
Unit value PT(Kč/min)	0.30	3.3	1.3	1.8
- Work	0.40			
- Other	0,14			

- Good for Czech conditions for city and regional transport
- Necessary to calibrate for the economy conditions out of Prague

Consolidation of Parameters of Time Value for Calibration

Comparison of two researches od stated preferences of Jacobs – time values				
Time values of one hour	**Babtie research 2005**		**Jacobs research 2008**	
	Time value of on hour (total) Kč/h	Time value of one hour IVT (Kč /h)	Time value of one hour IVT (Kč /h)	Time value of one hour (total) Kč/h
Praha				
PT user	*30*	20	20	36
Car user	65	48	39	73
Pardubice				
PT user	*26*	14		
Car user	54	31		

Consolidation of the parameters of time value

Time value / income				
Místo	In Vehicle Time Car + PT	Average anual income € 2006	Time value/ hour income	Source
Pardubice	0,9	6627	0,24	Survey Jacobs 2005
Praha	1,3	9609	0,24	Survey Babtie/Jacobs 2005, 2008
UK	5,7	44495	0,23	Web-TAG unit 3.5.6, DfT UK

Used Parameters for Calibration

H_{IVT}	Time value (PT+Car)	0.24 *medium salary in the region	Kč/hour
W_{pri}	Walk weight	4,4	
W_{cek}	Wait weight	1,8	
P_{pre}	„Fee“ for interchange	4,5	Kč/change

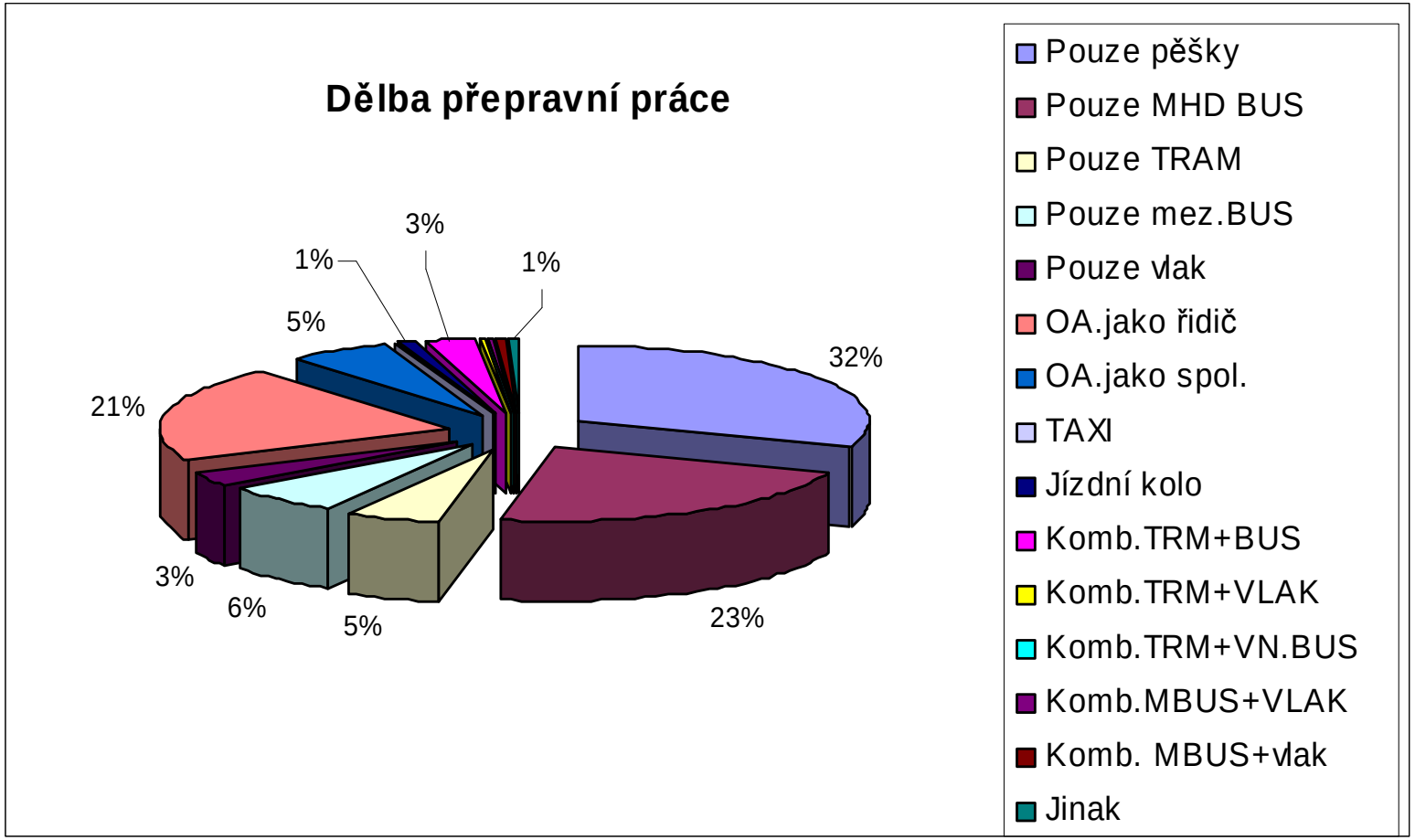
Standard Equotation

Generalised Cost Model

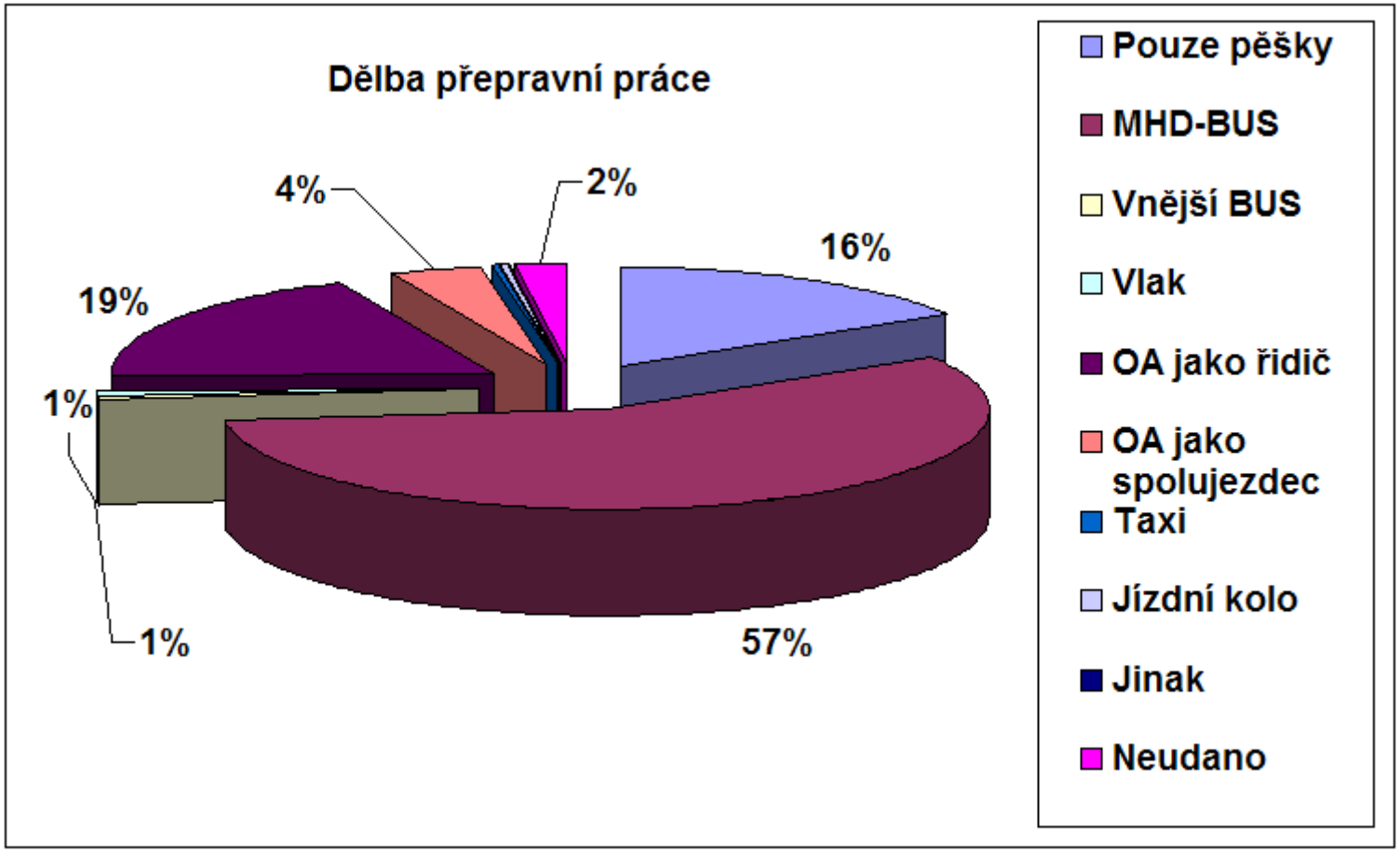
$$V_{CAR} = (Prov_{CAR} / O_{CAR}) + (VozCas_{CAR} \times H_{IVT}) + (PriCas_{CAR} \times Wpri \times H_{IVT}) + (Myto_{CAR} + Park_{CAR}) / O_{CAR}$$

$$V_{PT} = (PriCas_{PT} \times W_{pri} \times H_{IVT}) + (WaitTime \times W_{wait} \times H_{IVT}) + (CarTime \times H_{IVT}) + (PreCas \times P_{change}) + K_{headway} * (Int\text{-}X) + Fare + K_{HD\text{-}IAD}$$

Liberec region – Modal split



Plzeň Region – Modal Split

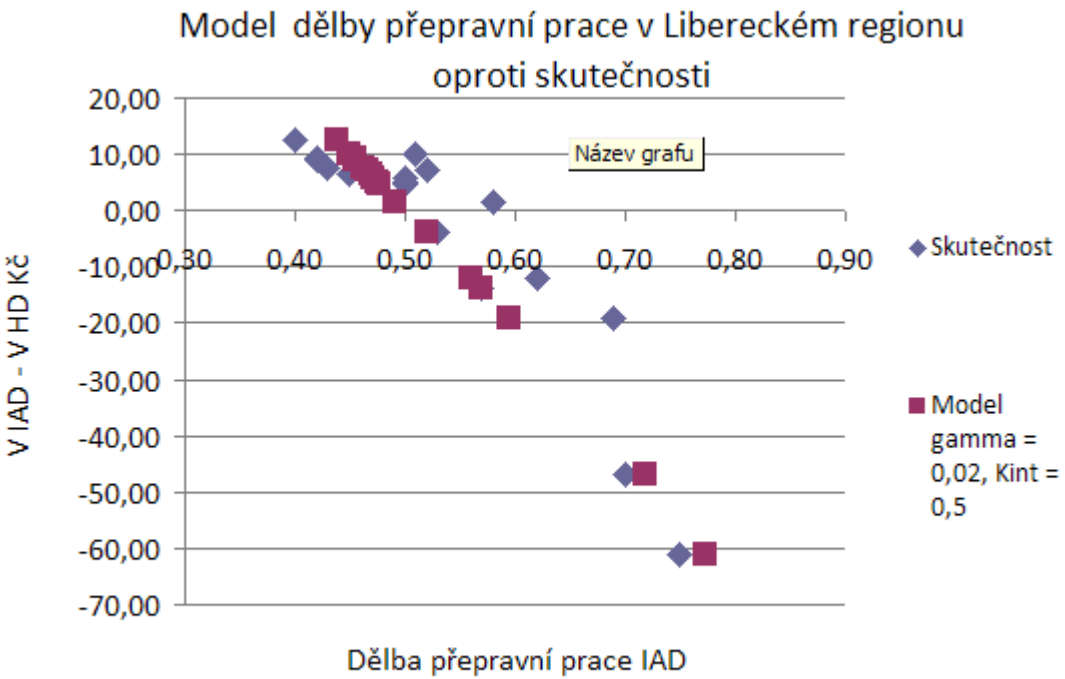


Modal Split

Modal split					
Region		% Car	% PT	% Walk	% Other
Liberec region		27 %	41 %	30 %	2 %
Plzeň region		23 %	59 %	16 %	2 %

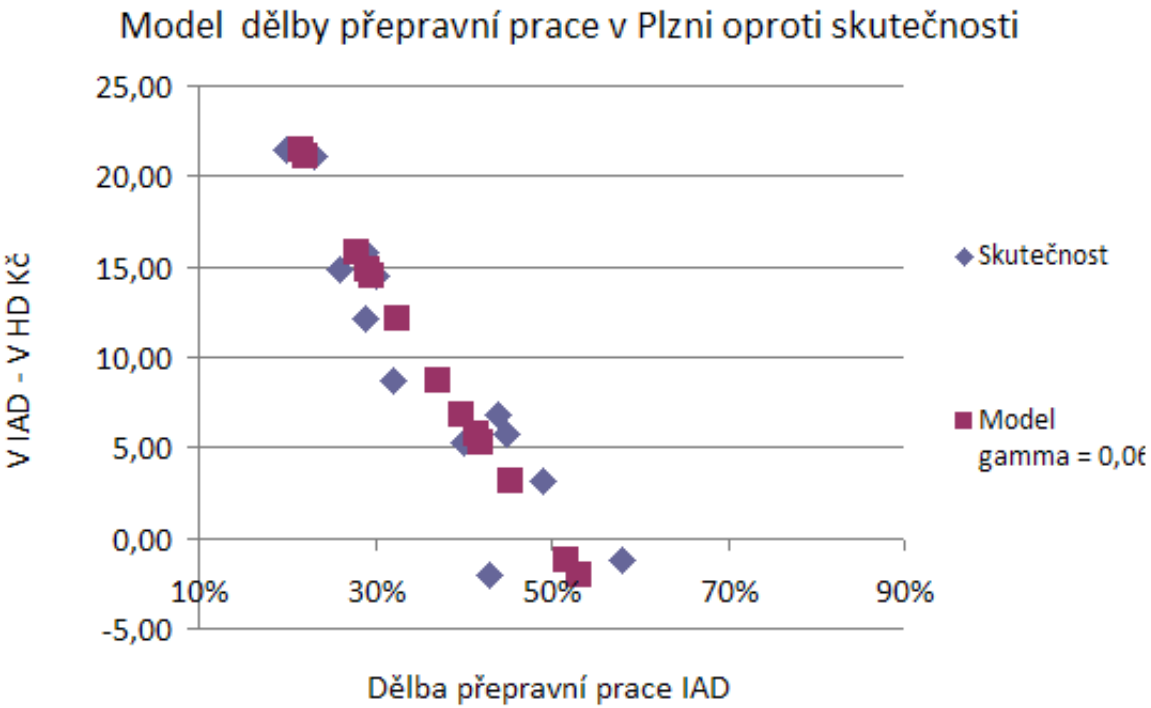
Car owners		% Car	% PT	% Other
Liberec region	4679	54%	26%	20%
Plzeň region	2245	41%	46%	13%

Model of Modal Choice - Liberec Region



GAMMA	#	K Car-PT	R^2
-0,01	2	-14	79%
-0,015	1	-14	79%
-0,02	0,6	-11	79%
-0,025	0,4	-10	77%
-0,03	0,2	-9	72%
-0,04	0	-9	53%
-0,05	0	-11	34%

Model of Modal Choice – Plzeň Region



G A M M A	K OA-HD	R^2
0,02	-19	46%
0,03	-12	61%
0,04	-5	74%
0,05	-2	81%
0,06	0	83%
0,07	1	83%
0,08	2	77%
0,09	2,5	69%
0,10	3	57%
0,11	3,5	43%

Model Example (category car owners)

Region	Liberec region		
Influence	P_{oa} real	P_{oa} model	P_{oa} model 2x (fare,park)
Fare	53 %	52 %	56 %
Parking fee	53 %	52 %	49 %
Region	Plzeňský region		
Influence	P_{oa} real	P_{oa} model	P_{oa} model 2x (fare,park)
Fare	36 %	36 %	47 %
Parking fee	36 %	36 %	21 %

Conclusions

- Model can be calibrated in real conditions
- Gamma is different from the city to the city
- Huge impact of PT headways in regional transport
- Useful tool for the assessment of planned changes impacts