Traffic impacts of road user charging – modelling and surveys

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Content of the presentation

- Why modelling toll effects – the crystal ball
- Our research project on urban road pricing **č. 1F41D/099/120**
  - Theory - modelling of the traffic impacts of RUC
  - Surveys for setting urban road pricing modelling parameters in CZ
- Some general conclusions

Why model traffic impacts of RUC systems ?

RUC is significant for route / modal choice / trip volumes

Traffic Reduction often **main aim of urban pricing**

Traffic Diversion

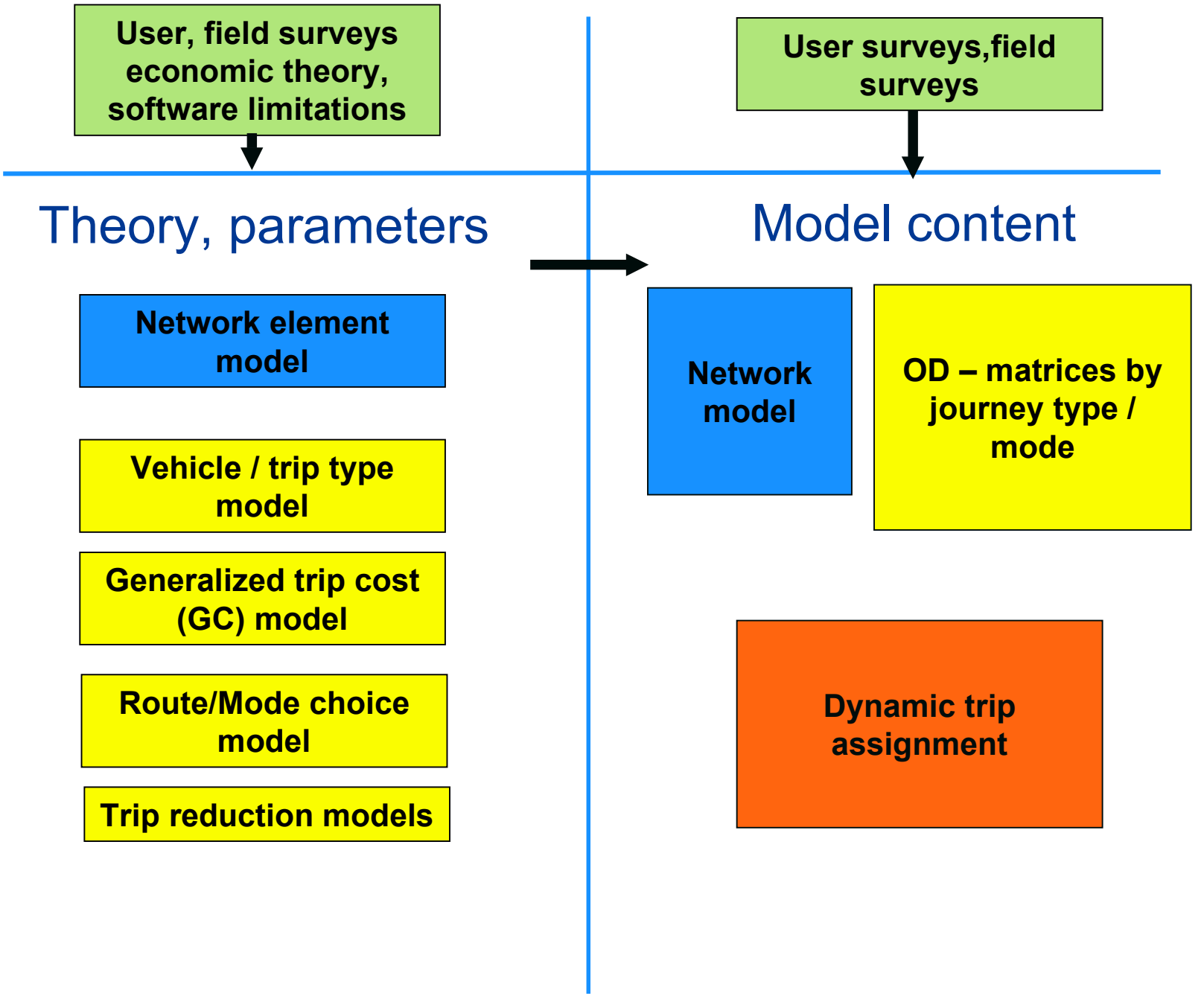
- Traffic diversion can have an impact on scheme income
- Traffic diversion can have a huge impact on acceptability
- We need to plan restrictive measures / set tolls in advance

„Wait and see“ approach dangerous for credibility and success

But can it be modelled accurately in advance ?

- Reasonably well if you have the right model with the right data
- Takes time, money and the right expertise

Ideal modelling process for tolls / RUC



Key concepts – Generalized Cost (GC) model for transport choices

- Relative perceived costs key
  - for choices between alternatives
- Generalized trip (GC) travel option costs = (for roads)

  OPERATIONS COSTS: DISTANCE × OPCOSTS/KM (mainly fuel)

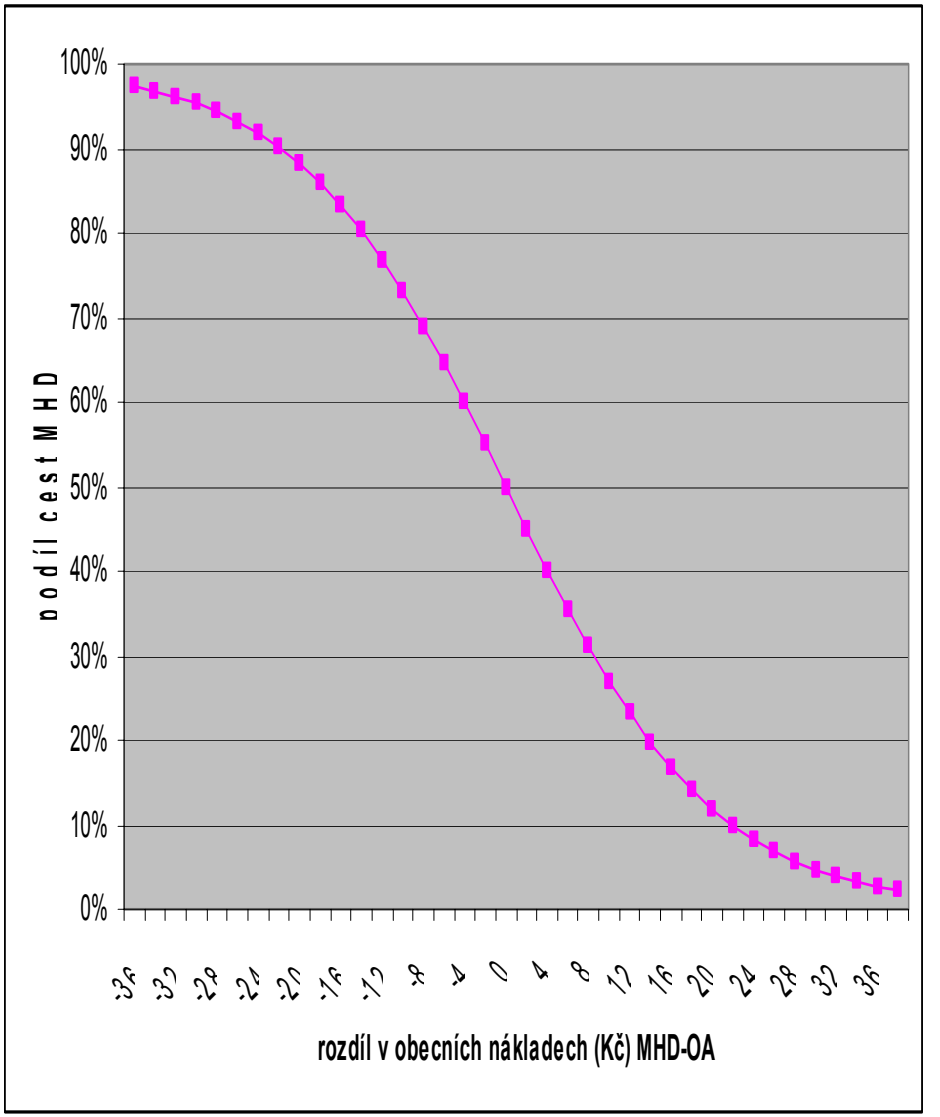
  + TIME COSTS: [DISTANCE ÷ SPEED + WAITING] × TIME VALUE/HR

  + CHARGES: TOLL(/KM ?) + PARKING + FARES ETC.
- Choose the lowest GC option
- In reality GC option modelling is complex at macro level because…
- GC Parameters vary for
  - different user characteristics e.g income
  - different trip types e.g. work, commuting, leisure
  - sometimes high modal / route penalties

➢ Capturing variation in realistic and simple enough way is key to good model

Key concepts –Mode Choice model based on GC

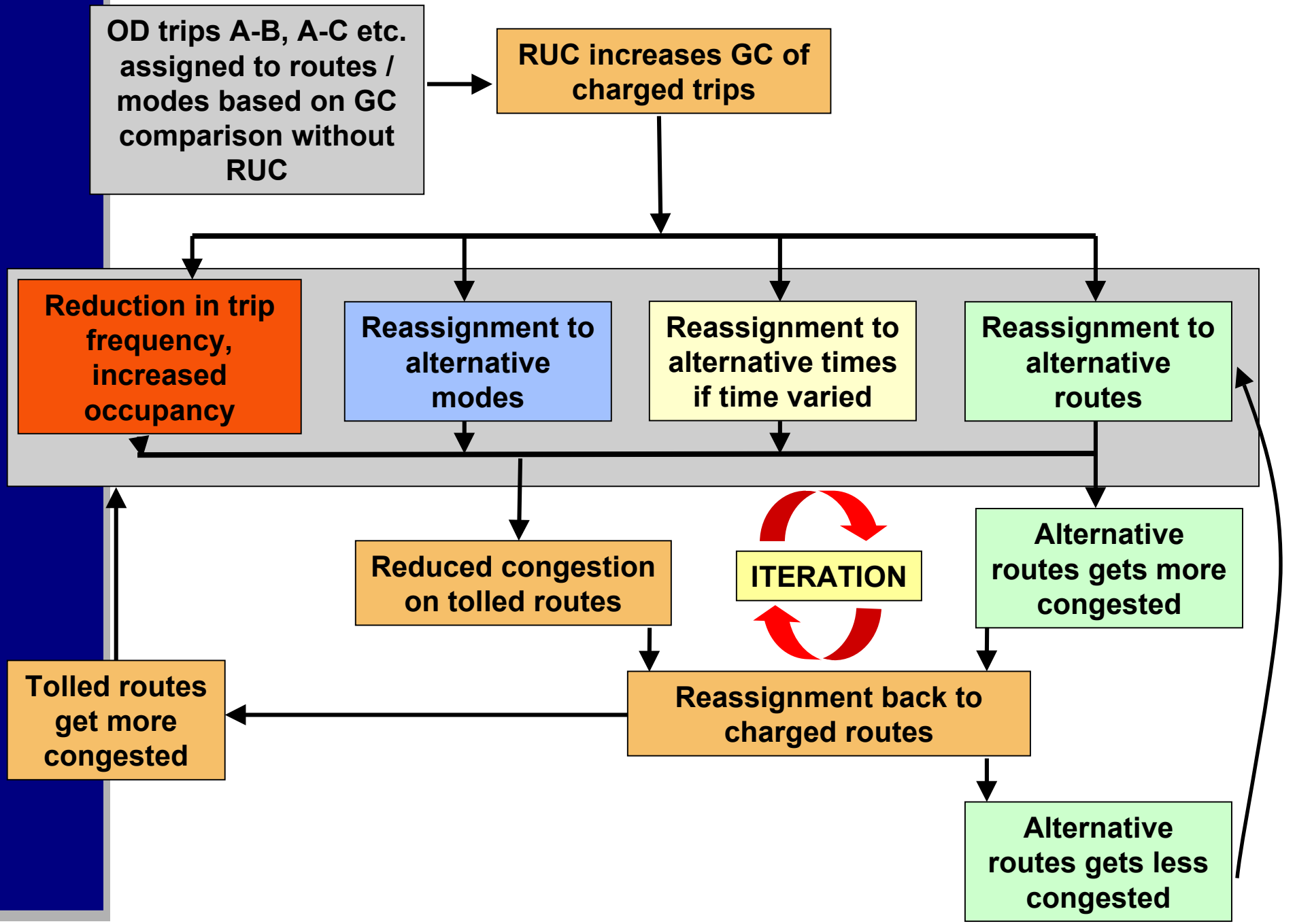
- **Logit models** used on relative **GC** to capture variation for mode shift
  - mode or route captives (safety, familiarity, obligation, physical need etc.) on all choice sides
  - characteristic sensitivity to changes of toll /charge (B). Need to find this out in surveys
  - per O-D relation



Key concepts – Route Choice model based on GC

- **„All-or-nothing – least GC route“** is often used for route choice
  - when wide enough diversity of modelled trip types and O-D relations
  - and/or with statistical variation of unit time value as an individualisation effect
  - per O-D relation

Key concepts – Dynamic assignment of trips with tolls



The secret to good modelling of tolls / user charges

- Get the right level of model detail and data quality
  - dissagregation to enough trip types
    - for car trips business, commuting, leisure
    - need O-D surveys at this level of dissagregation
  - corresponding route/mode choice method(s) and underpinning GC model
    - need user behaviour surveys to set choice model parameters
- Thorough calibration and validation of the basic model against the current state (no toll, charge) – travel times, volumes, modal split
- Software fit for the task (not just what we know)
- Sensitivity analysis on uncertain key parameters

The secret to good modelling of tolls / user charges

User behaviour surveys for choice model parameter setting

- asking users how they make travel decisions
- asking users how they value their time / operations
- asking users what they would do if a toll was imposed
- asking the questions in the right way

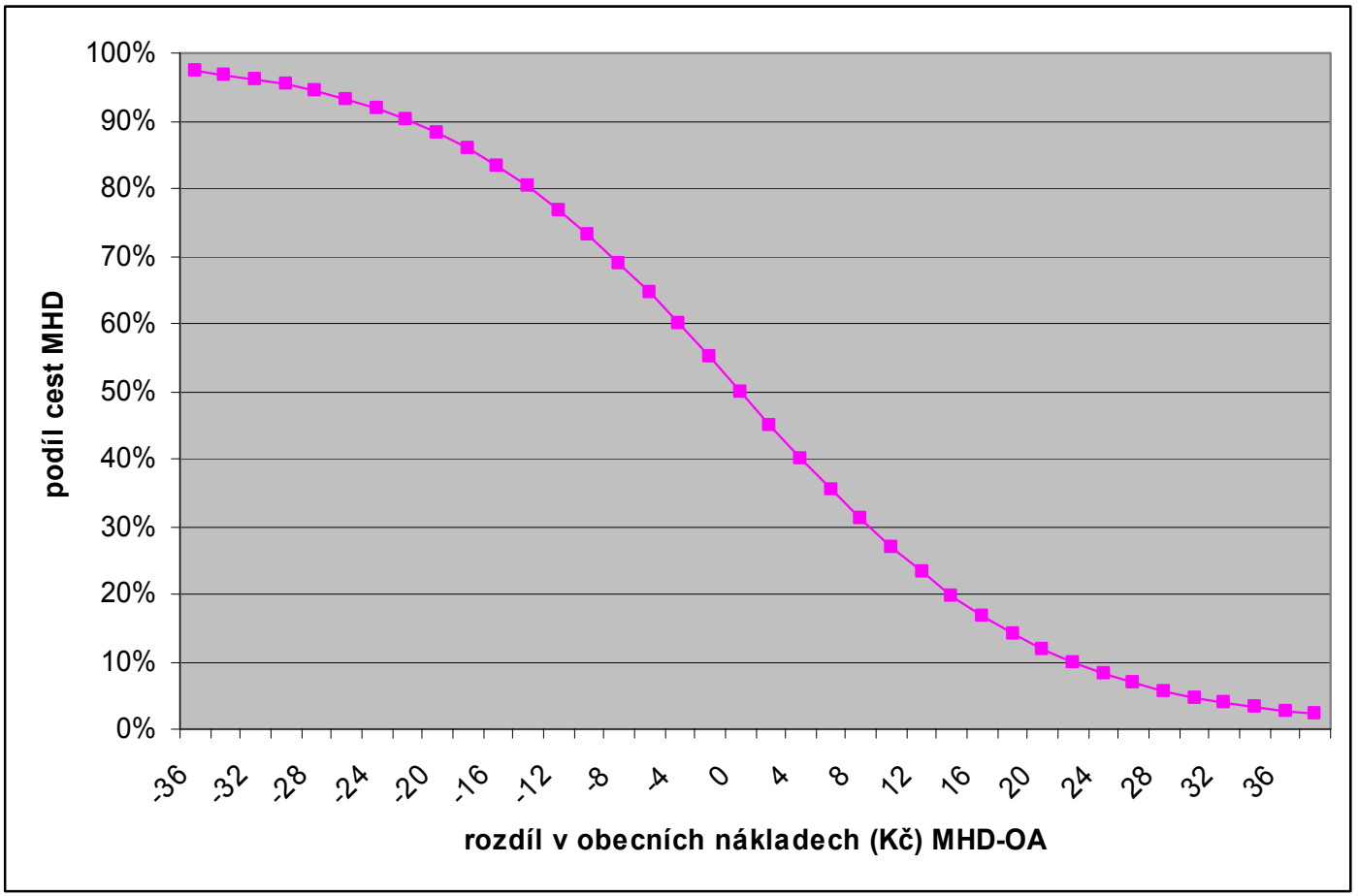
.....

- key for understanding and modelling
  - decision processes
  - modal shift, trip timing shift, trip frequency sensitivity parameters
  - GC parameter variation (time valuation)

Our User Behaviour Surveys **in the research project**

- Stated Preference Surveys (SPS) for urban road pricing behaviour in Prague and Pardubice
- Demonstration and testing of method
- Derivation of some modelling parameters in these two cases
  - Perceived value of time of car users
  - Trip timing shifts sensitivity relative to charge rate for peak charges
  - Trip frequency reduction sensitivity relative to charge rate
  - Modal shift sensitivity relative to charge rate (B)

Key concepts – Typical Binary Logit Mode Choice Model : Modal split (y) against difference in GC (x)

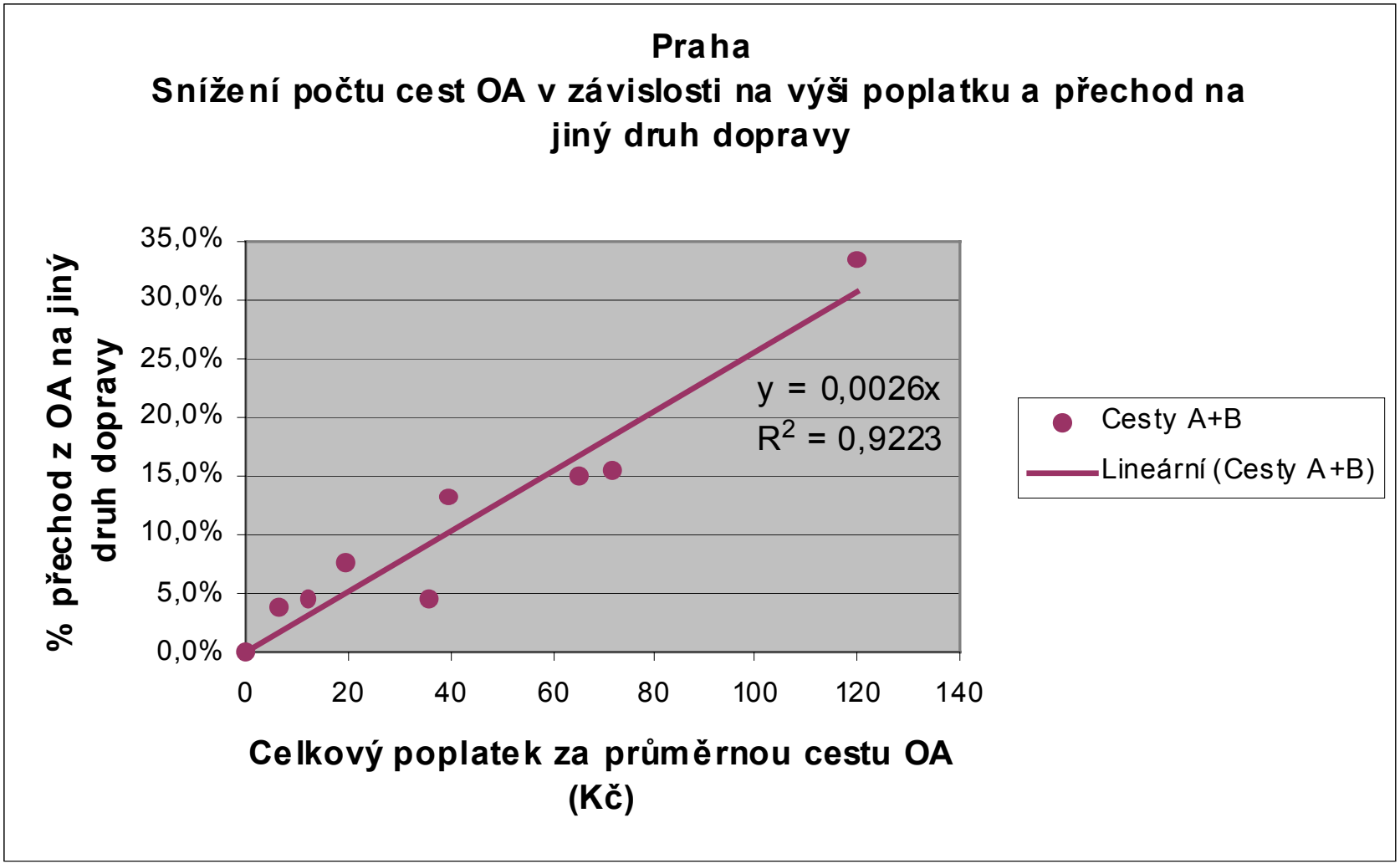


$$P(m_1) = \exp[-B*ON(m_1)] / [\exp[-B*ON(m_1)] + \exp[-B*ON(m_2)]]$$

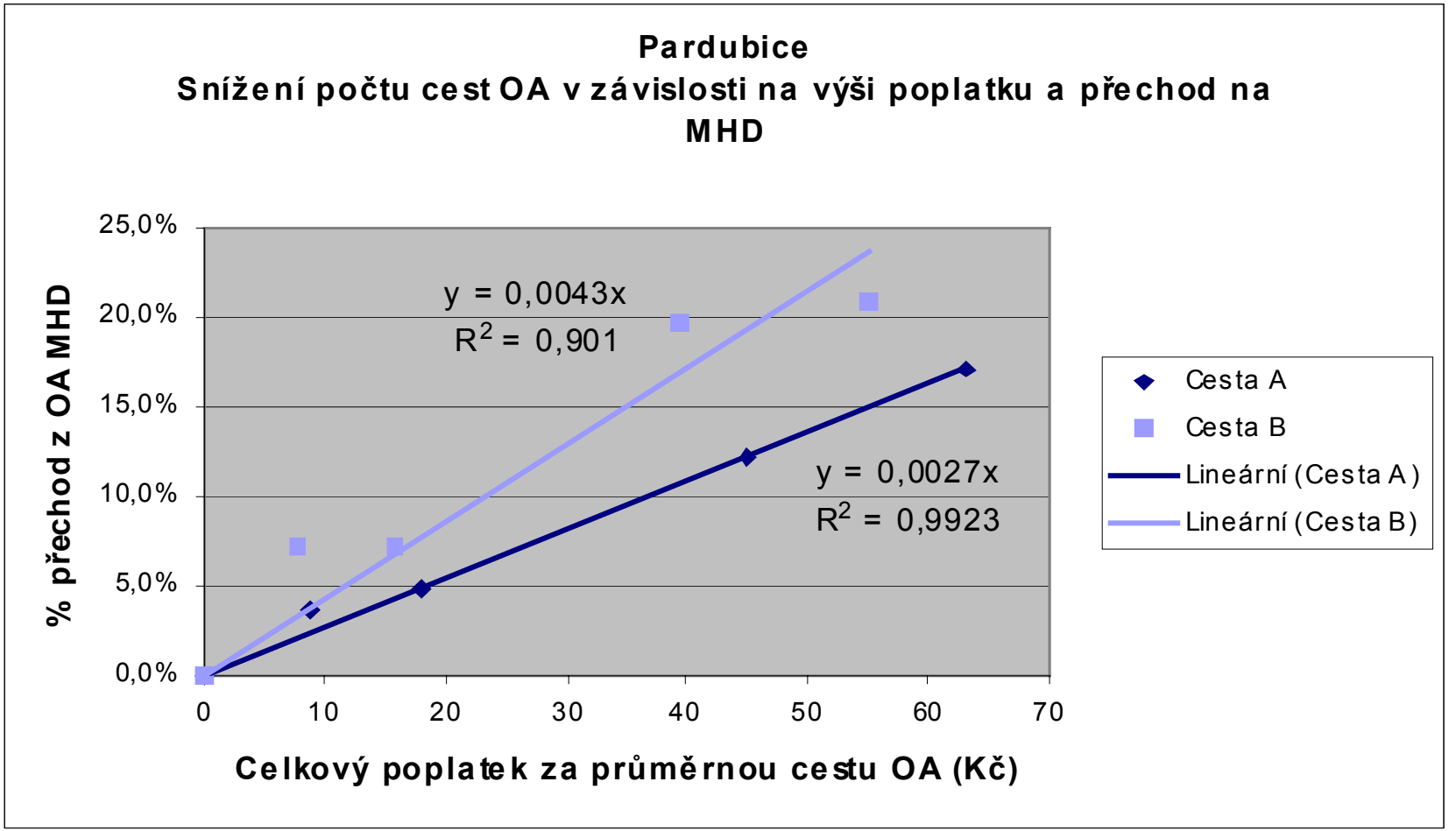
SPS questionnaire for urban pricing models

- asked respondents to describe behaviour changes
  - with various km based urban charges of increasing value
  - for typical commuting (A) and other non-work trips (B) separately
- asked respondents willingness to pay for reduction in typical journey times (time valuation)
- ascertained personal (e.g. income) and trip details

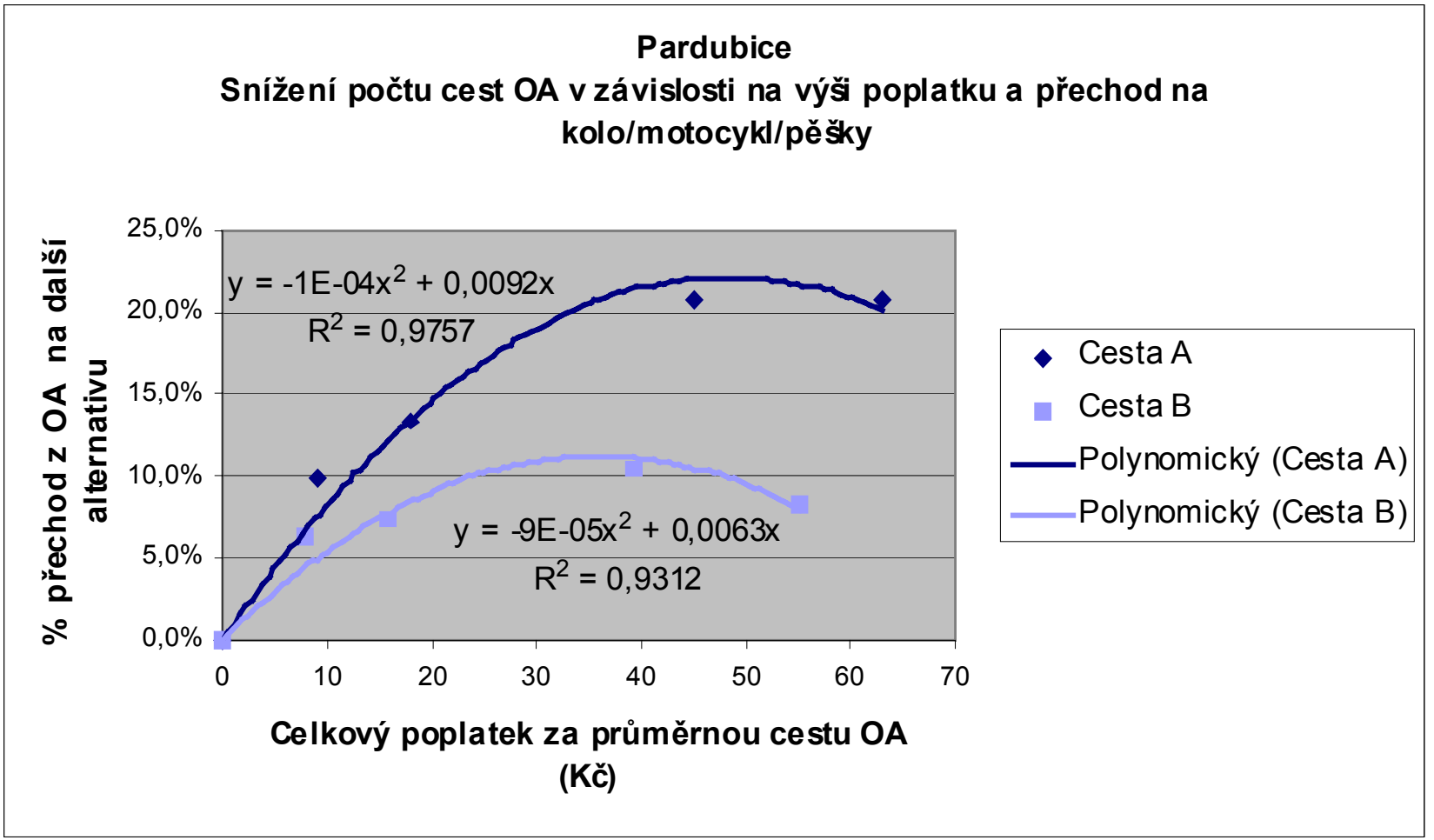
Transfer of car trips to PT against average day charge – Praha
100 CZK / day > - 25 % commuting and recreational



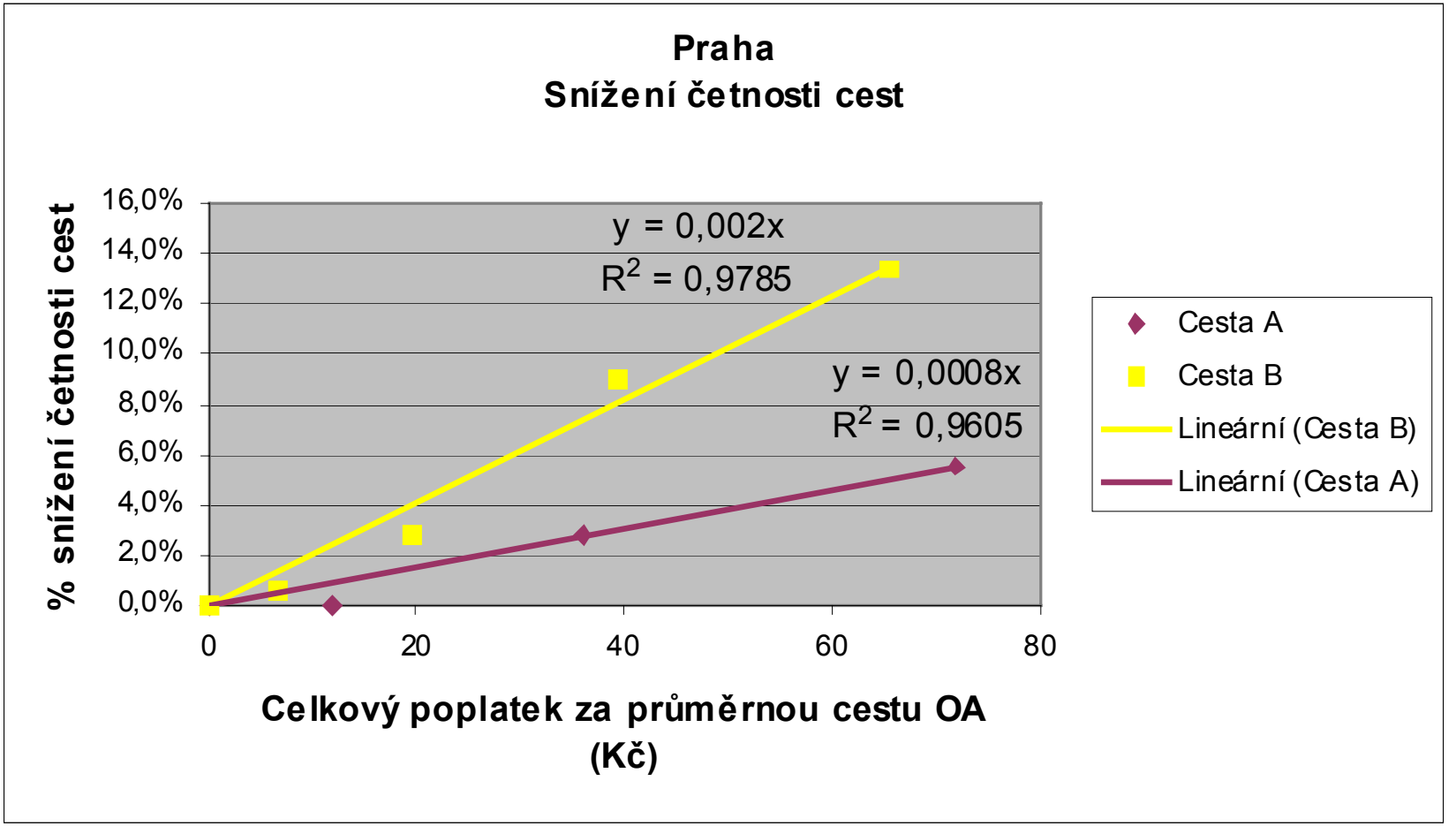
Transfer of car trips to PT – Pardubice
50 CZK / day > - 22 % recreational, - 12 % commuting



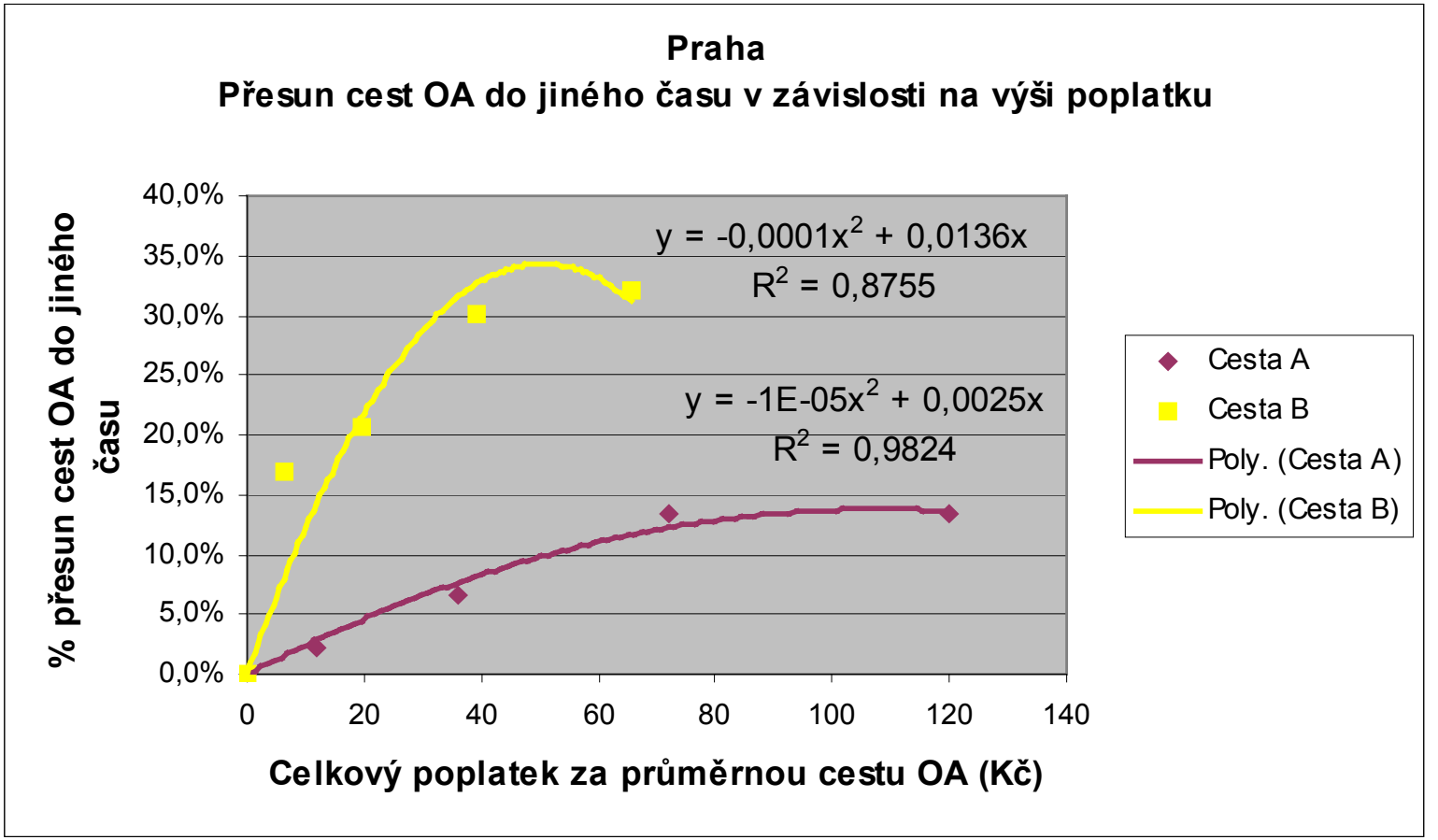
Transfer of car trips to bike and walk – Pardubice
50 CZK / day > - 20 % commuting, - 12 % recreational



Reduction in frequency of trips – Prague
50 CZK / day > - 5 % commuting, - 10 % recreational



Off- peak time shift of car trips ,with peak time charge – Prague 100 CZK / day > - 15 % commuting, - 30 % recreational

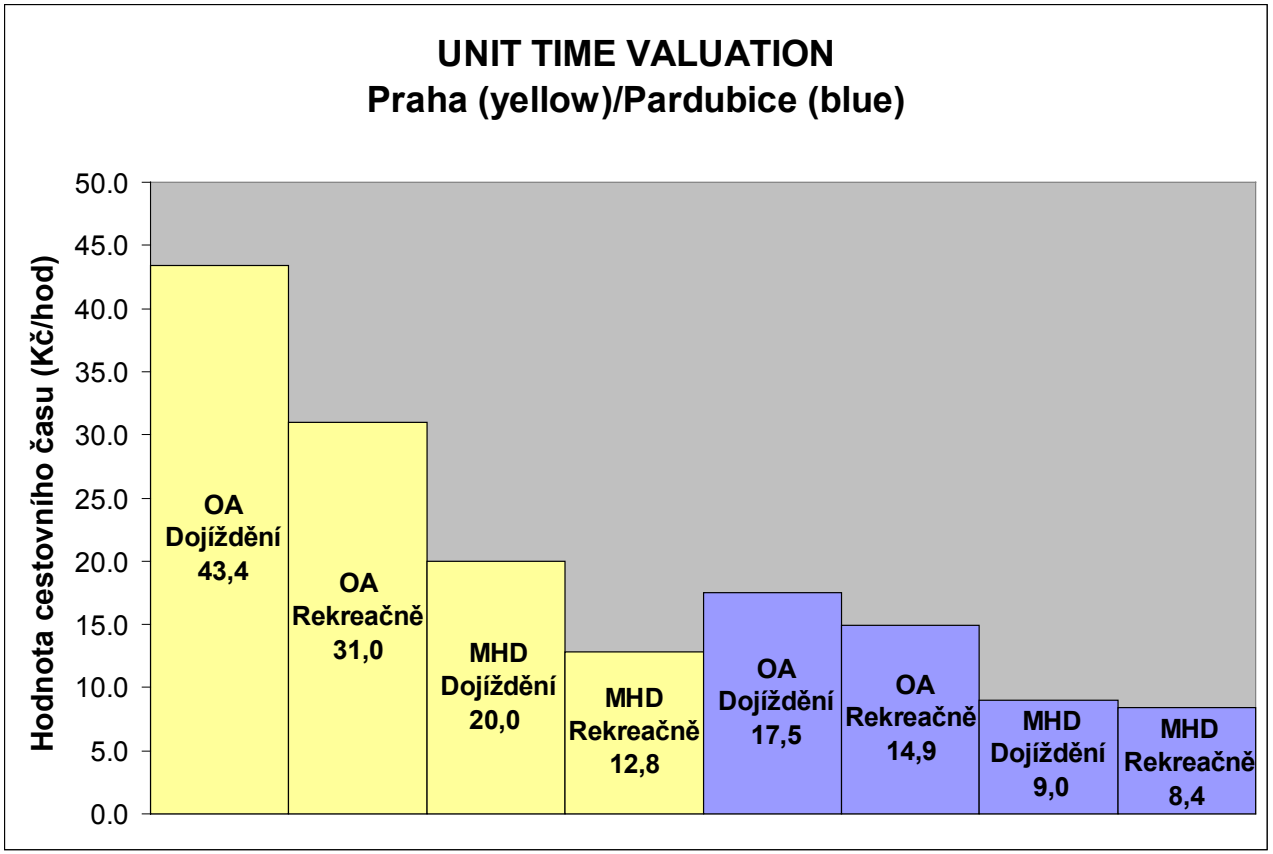


Urban road pricing in Czech conditions

Summary of car trip reduction effects

- In Prague the main impact of the toll is from car to PT
- In Pardubice we would see a major shift to bike traffic
- An average 100 CZK all day charge in Prague could reduce affected commuting and recreational car traffic by circa. 35 %
- Peak charge shifts are high for recreational traffic (up to 30 %)

Urban road pricing in Czech conditions – time valuation



Hodnota cestovního času (Kč/hod) v **Praze**				
Druh cesty	OA		MHD	
Dopravní prostředek	A	B	A	B
Stř. hodnota	43,4	31,0	20,0	12,8
Hladina spolehlivosti (95,0%)+/-	*23,1*	*21,6*	*5,4*	*6,2*
Hodnota cestovního času (Kč/hod) v **Pardubicích**				
Druh cesty	OA		MHD	
Dopravní prostředek	A	B	A	B
Stř. hodnota	17,5	14,9	9,0	8,4
Hladina spolehlivosti (95,0%)+/-	*8,1*	*7,9*	*6,4*	*8,0*

Urban road pricing in Czech conditions

UNIT TIME VALUATION

- Major difference
  - between car and PT users
  - and between Prague and Pardubice
- 50% declared indirectly that they do not value their travel time in their personal travel context.
  - this is probably a methodology problem
    - we asked the question badly
    - more personal approach needed
  - average values are thus probably low
  - it deserves further and closer attention

Summary and conclusions

OUR RESEARCH

- Given some insights into urban charge modelling and user survey methodology in theory and practice, some rough logit model and GC parameter values for urban charging
- Much more work is needed to understand freight traffic and car trip behaviour under tolling conditions

GENERALLY

- We have to take modelling methods and travel behaviour data collection much more seriously if we want to predict user behaviour in the face of tolling and user charges
- Otherwise we will have to stay with „wait and see“ strategy

Modelling software

MODELLING REQUIREMENTS

- **Need dynamic generalized cost modelling**
- **Ability to model more modes of transport**
- **Need dynamic assignment option with quick iteration**

SOFTWARE

- **A job for flexible static modelling programmes – TRIPS, EMME/2 SATURN, VISSUM, CONTRAM etc.**
- **Simulation environments getting better but not yet very suitable for dynamic assignment PARAMICS, AIMSUN**

Models which do not work well generally

- Use foreign assumptions and parameters
- Have poor O-D data
- Have not been calibrated and validated against the current state :
  - modal split of O-D relations
  - traffic volumes by vehicle type
  - travel times
- Assignment, O-D or GC model is too simple

Impact of Toll on Freight diversion for I-81 in Virginia

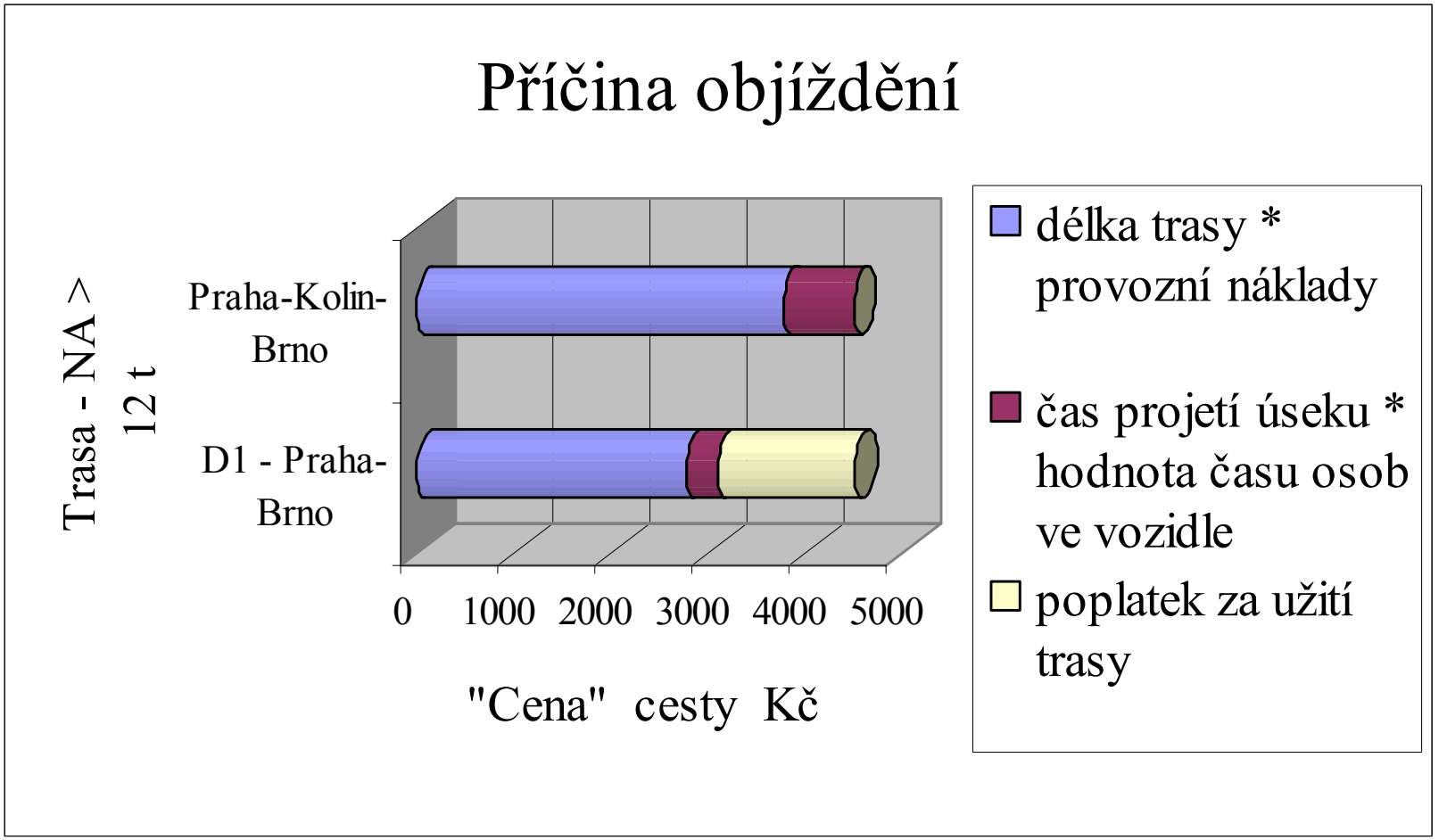
Route choice

Next Best Alternative Routing – Memphis, TN to New York, NY

Where do we stand in the Czech Republic ?

- Research project of City-Plan from 2004-2005 (IF51D/119/120)
  - first serious full attempt at modelling HGV toll impacts in CR
  - within research programme in VISSUM
  - suggests that 4 CZK / km for HGV will give a circa 5 % diversion with quite some route-by-route variation
  - stochastically varied unit time value GC model, route choices based on relative GC
- Some model + and -
  - ✪ stochastic variation is sensible
  - ✪ senstivity analysis on average time value
  - ☆ travel time only GC is pragmatic but imprecise for freight
  - ☆ little local source data for the model except some counts
  - ☆ key unit and route values, route choice logic all uncalibrated by local haulier behaviour surveys, travel time data ?
  - ☆ no distinction between “western” European, “eastern” European and local trucks

Key concepts – Example of route GC comparison with toll for Czech HGV system



Best practice - Impact of Toll on Freight diversion for I-81 in Virginia

Details of model

- Interstate 81 freeway in Virginia improvement to be financed by freight toll
  - needed to know impacts on freight diversion / income by toll rates
- Diversion model
  - ✪ extensive routing decision process survey with hauliers
  - ✪ huge database on freight carrier types, volumes, vehicle types, trip patterns, commodities and operating costs
  - ✪ national freight flow model (O-D database by commodity type)
  - ✪ GC truck operating cost model based on mileage, time, route - type, toll, by equipment-commodity type
  - ✪ next-best alternative, least-cost all-or-nothing route choice per equipment-commodity type
  - ✪ enough diversity for a good model
  - ☆ not dynamic, congestion effect not tested

Impact of Toll on Freight diversion for I-81 in Virginia

Results of model and surveys

- little transfer to poorer alternative routes for safety policy reasons
- high diversion of short trips with OK alternative even with low toll
- ...then longer trips come in with higher toll
- logit shape of diversion-toll vehicle volumes
- recommended toll level of 6-12 cents / km
  - with diversion of 8-15 % of vehicle kms
- good example of high data diversity non-stochastic model

Impact of Toll on Freight diversion for I-81 in Virginia

Results of model – vehicle miles diverted against toll

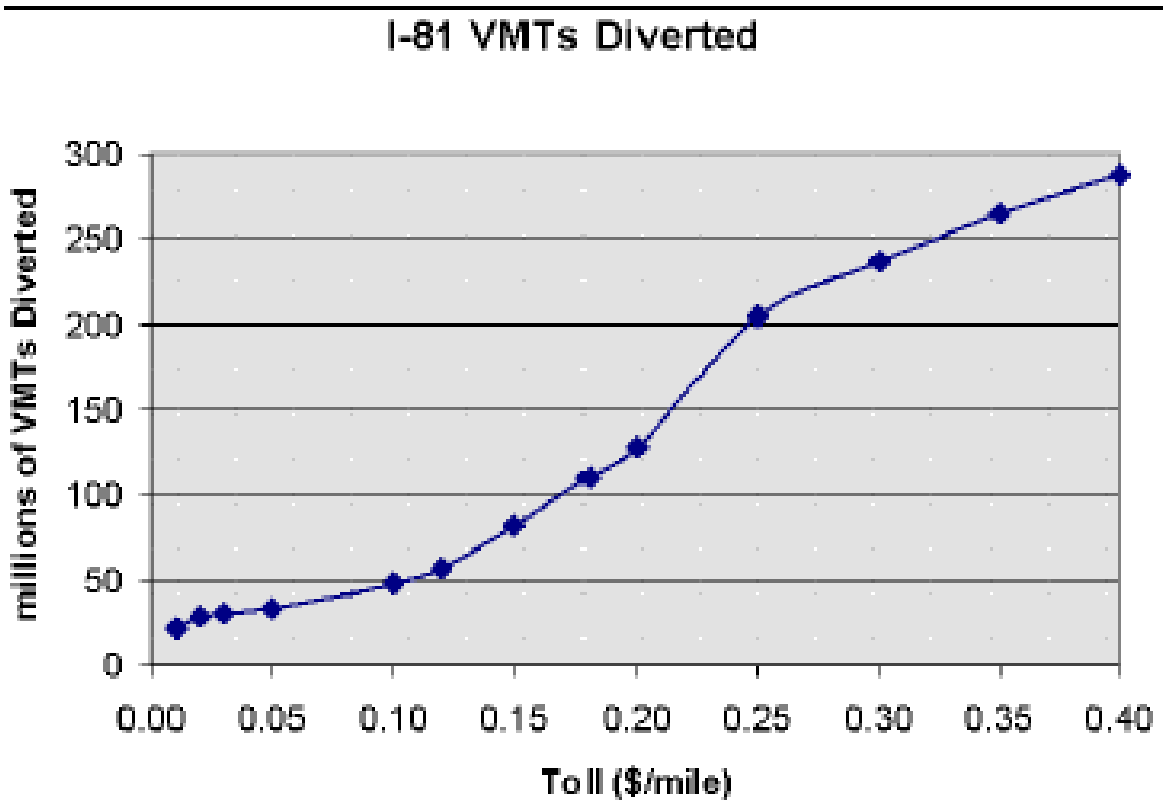


Figure 3: I-81 Vehicle Miles Diverted at Various Toll Amounts (2003 Volumes)

Where do we stand in the Czech Republic ?

- For Czech freight tolling scheme
  - we have not used the rich freight O-D data available at region to region level for domestic carriers
  - know little about foreign carrier trip movements
  - we don’t really know how real companies choose routes for different vehicles, distance, equipment-commodity types
  - we don’t understand local freight transport costs in depth and detail
  - **freight toll models here so far** have suffered from lack of detail and localisation due to lack of data or failure to use existing data or are more „what-if“ impact models
- For urban car trips
  - in O-D data collection, we rarely make a distinction on trip types
  - recent research project gives some insight into user charge behaviour parameters

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Increase in car occupancy of car trips – Prague
100 CZK / day > - 5 % commuting, - 0 % recreational