Thresholds in choice behaviour and the size of travel time savings

Session 45: Value of time II

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Toulouse, 6th June 2014

Outline

1. Problem statement
2. Modelling approach
3. Application to synthetic data
4. Application to stated choice data
5. Conclusions

1 Problem statement

Small travel time savings

- Travel time savings usually comprise a large part of economic benefits of transport infrastructure projects; often caused by small time savings for single persons.

- Are small travel time savings of lower, if any, unit value for individuals?

- There exist several arguments against using a discounted unit value for small travel time savings for **project appraisal**.

- It is **not** the aim of this presentation to assess these arguments.

1 Problem statement

Focus of our research

- Empirical issues in estimating time thresholds with discrete choice models.

- Consequence of ignoring them in model estimation: VTTS might be downward biased.

- This issue has to be addressed separately from the question whether time thresholds should be considered in benefit-cost analyses.

2 Modelling approach

What we want to model

- People can choose one of two alternatives (e.g. route choice).

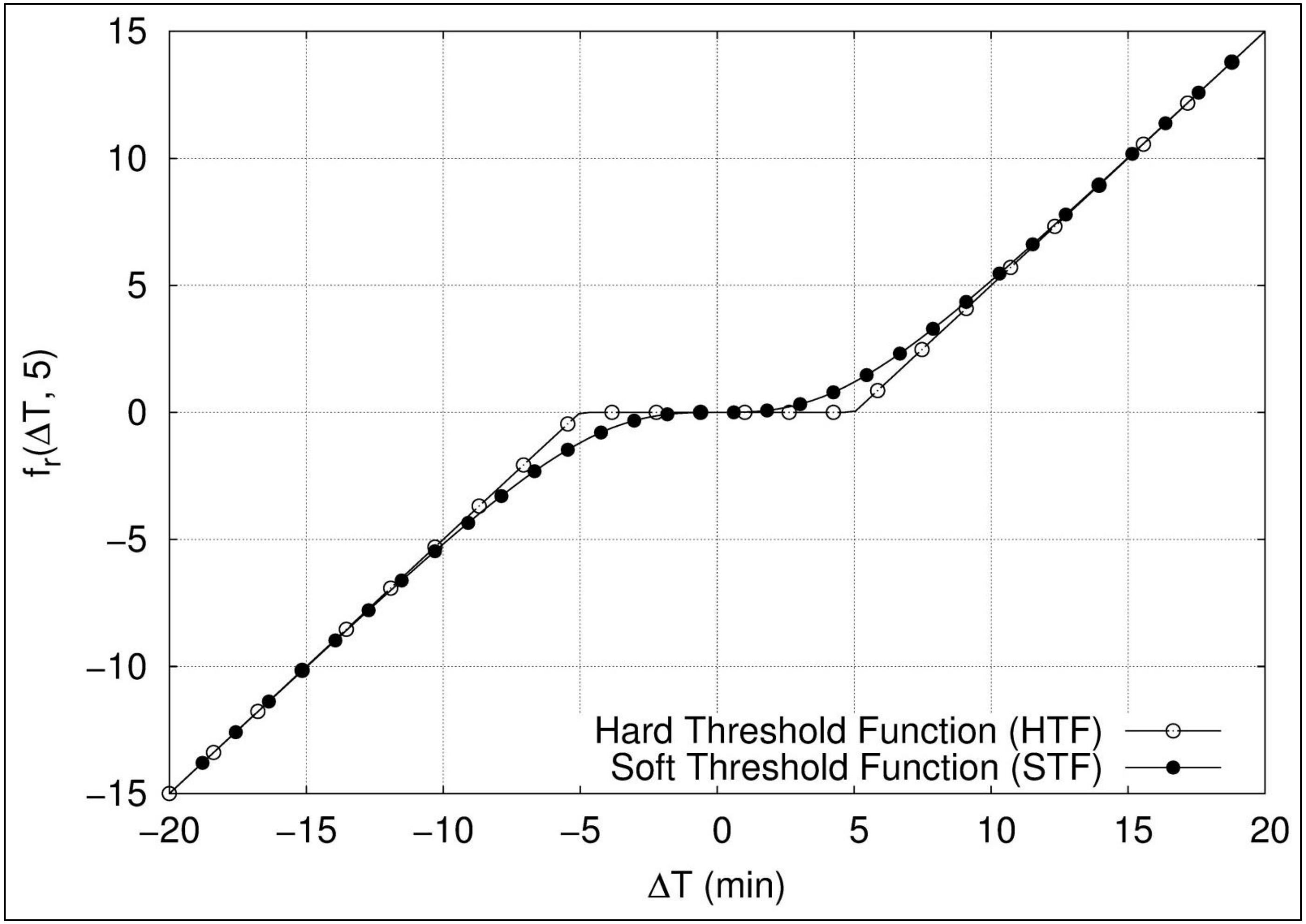
- Standard binary choice model:
  - People choose the alternative from which they obtain the highest utility.
  - Utility (U) is decomposed into a deterministic (V) and a stochastic part (ε).
  - Stochastic part is assumed to be i.i.d. Gumbel (logistically distributed differences).

- People may exhibit different sensitivities for small and large time differences. If this is the case, substitution between time and cost is different for small and large time changes.

- Model needs to reproduce different sensitivities for small and large time changes (below and above a threshold).

2 Modelling approach

Form of transformation functions



2 Modelling approach

Transformation functions

$$f_{HTF}(\Delta T, \alpha_{HTF}) = \begin{cases} 0 & \text{abs}(\Delta T) < \alpha_{HTF} \\ \text{sign}(\Delta T) * (\text{abs}(\Delta T) - \alpha_{HTF}) & \text{abs}(\Delta T) \geq \alpha_{HTF} \end{cases} \tag{1}$$

$$f_{STF1}(\Delta T, \alpha_{STF1}) = \Delta T - \alpha_{STF1} \tanh\left(\frac{\Delta T}{\alpha_{STF1}}\right) \tag{2}$$

$$f_{STF2}(\Delta T, \alpha_{STF2}) = \Delta T \left(1 - 1/\sqrt{\left(\frac{\Delta T}{\alpha_{STF2}}\right)^2 + 1}\right) \tag{3}$$

$$f_{Power}(\Delta T, \alpha_{Power}) = sign(\Delta T) * abs(\Delta T)^{\alpha_{Power}} \tag{4}$$

3 Application to synthetic data

Generating synthetic data

- Synthetic database with two alternatives and 5000 records.
- Utility difference calculated according to:

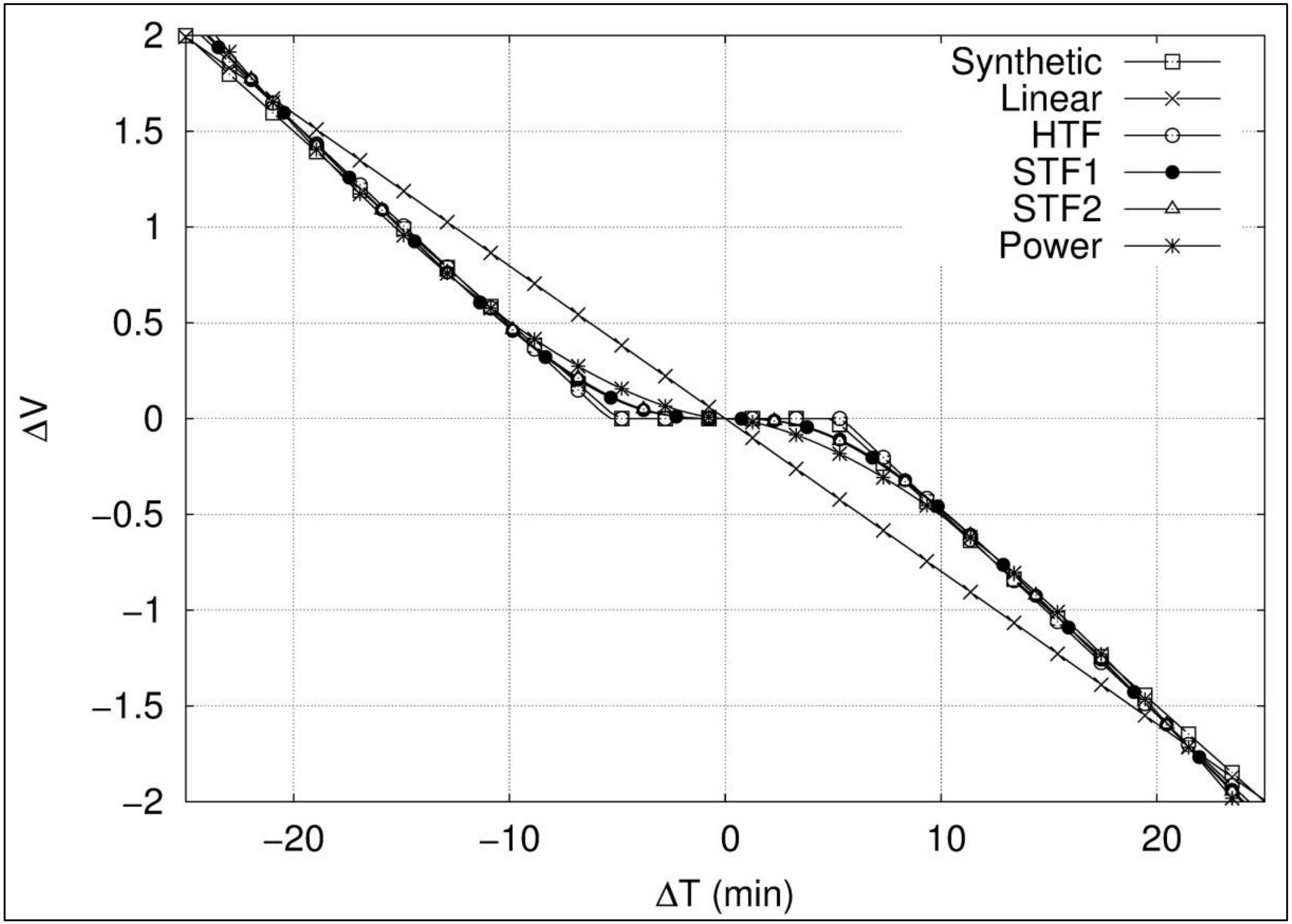
$$\Delta U(\Delta T, \Delta C) = \Delta V(\Delta T, \Delta C) + \Delta\varepsilon$$
$$= \beta_T * f_{HTF^*}(\Delta T, \alpha_{HTF^*}) + \beta_C \Delta C + \Delta\varepsilon \tag{5}$$

- Cost and time differences have been assumed to be independent and uniformly distributed in the range of [-10, 10 CHF] and [-25, 25 min], respectively.

- Individual chooses alternative with the highest total utility ($\Delta U > 0$ → Individual choses alternative one).

3 Application to synthetic data

Estimation Results I



3 Application to synthetic data

Estimation results II

	Synthetic	Linear	HTF	STF1	STF2	Power
Cost	-0.600	-0.630 * (0.12)	-0.596 * (0.83)	-0.598 * (0.92)	-0.598 * (0.92)	-0.602 * (0.92)
Time	-0.100	-0.080 * (0.00)	-0.106 * (0.47)	-0.113 * (0.35)	-0.119 * (0.26)	-0.013 + (0.00)
Alpha	5.000	---	5.410 * (0.69)	6.34 * (0.45)	7.48 * (0.29)	1.600 * [0.00]
Null-LL	-3465.736					
Final-LL	---	-1787.714	-1779.042	-1779.105	-1779.051	-1779.064
***, #, + Significant on 1%, 5% and 10% levels, respectively. (.) p-value for null hypotheses that parameter is equal to its target value. [.] p-value for null hypotheses that parameter is equal to one.**						

3 Application to synthetic data

Estimation results III

- HTF and the two STF fit really well and reproduce the target values.

- Despite the good fit of the power function the estimated time coefficient is significantly different from its target value.

- Linear specification has also been estimated to examine the error when ignoring the threshold.
  - Time coefficient has not been reproduced correctly.

- Many observations are necessary to detect an existing threshold.
  - For 5000 observations the log-likelihood difference between the linear and the threshold models is just about 9 units.

4 Application to stated choice data

Data

- Route choice experiments for commuting trips by train in Switzerland (from Swiss value of travel time study).

- Respondents had to choose between two routes which were characterised by the attributes travel time (T), travel cost (C), headway (H) and the number of changes (K).

- 1600 observations from roughly 180 respondents.

- Range of time differences varies from one minute to around 45 minutes with 20 per cent of the observations less than or equal to two minutes.

4 Application to stated choice data

Deterministic utility

$$\Delta V(\Delta T, \Delta C, \Delta H, \Delta K, I, T) = \beta_T * f_r(\Delta T, \alpha_r) + \beta_C \Delta C * \left(\frac{I}{\bar{I}}\right)^{\lambda_I} * \left(\frac{T}{\bar{T}}\right)^{\lambda_T} + \beta_H \Delta H + \beta_K \Delta K \quad (6)$$

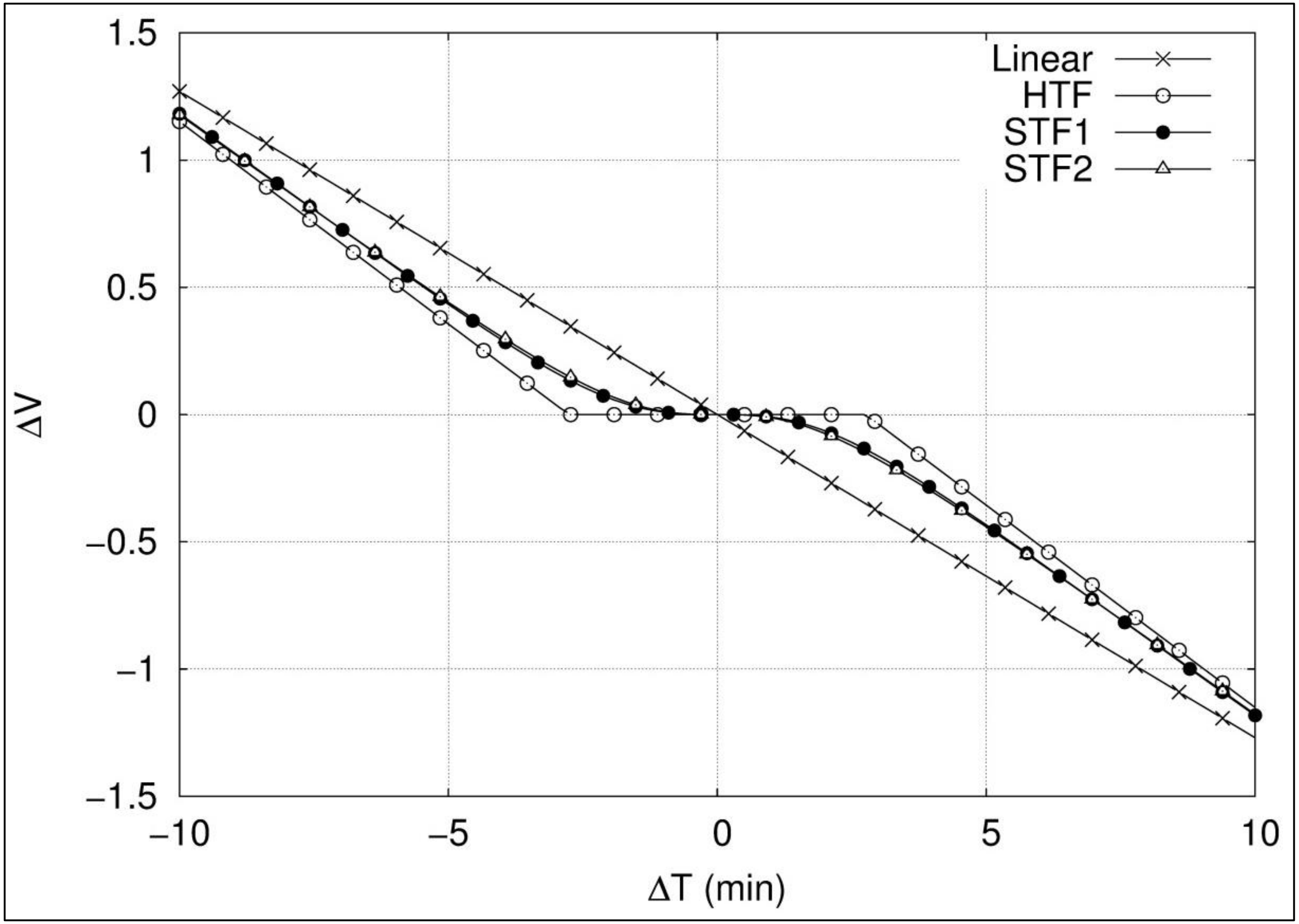
λ_I: Income elasticity (VTTS depends on income)

λ_T: Travel time elasticity (VTTS depends on travel time; journey length)

- Transformation functions described earlier applied (Power function omitted).

4 Application to stated choice data

Estimation results I



4 Application to stated choice data

Estimation results II

	Linear	HTF	STF1	STF2
Cost	-0.305 *	-0.274 *	-0.285 *	-0.286 *
Time	-0.127 *	-0.159 *	-0.151 *	-0.152 *
Alpha	---	2.760 *	2.170 #	2.310 #
Headway	-0.050 *	-0.051 *	-0.051 *	-0.051 *
Changes	-1.420 *	-1.430 *	-1.430 *	-1.430 *
Income Elasticity	-0.252 *	-0.251 *	-0.250 *	-0.249 *
Time Elasticity	-0.489 *	-0.347 *	-0.387 *	-0.391 *
Scale [a]	0.797 [*]	0.787 [*]	0.790 [*]	0.790 [*]
Null-LL	-1110.422			
Final-LL	-687.064	-684.184	-684.651	-684.798
LL-ratio test against Linear	---	0.02	0.03	0.03

*, #, + Significant on 1%, 5% and 10% levels, respectively.

[.] Significance level for null hypotheses that parameter is equal to one.

[a] Controls for error scale differences.

[b] Asymptotic value of travel time savings in CHF per hour.

4 Application to stated choice data

Estimation results III

- Across all three transformation functions, significant threshold parameters have been estimated → threshold of two to three minutes.

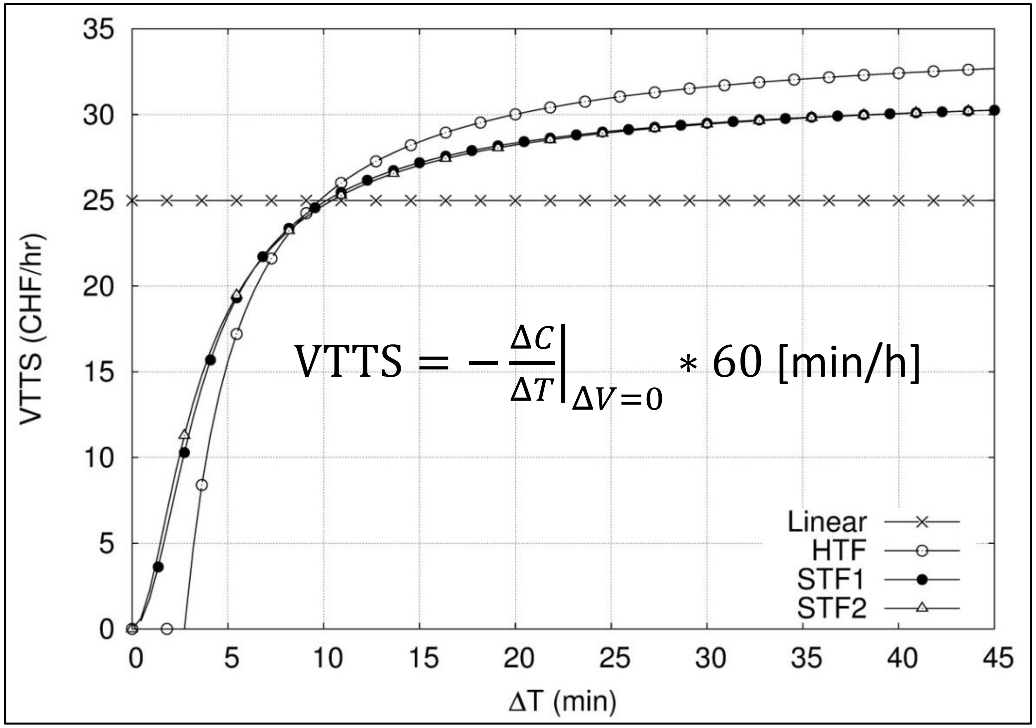
- Likelihood-ratio tests show that the HTF and the STF are significantly better than the linear model.

- "Horowitz (1983) - Test" shows STF formulations perform not significantly worse than the HTF model.

4 Application to stated choice data

Value of travel time savings

- According to the threshold formulation VTTS is lower for small time changes and higher for large time changes in comparison to the linear model.



$$\text{VTTS} = -\frac{\Delta C}{\Delta T}\bigg|_{\Delta V=0} * 60\ [\text{min/h}]$$

- Consideration of thresholds leads to substantially higher asymptotic VTTS.

	Linear	HTF	STF1	STF2
VTTS (CHF/hr.)	24.98	34.82	31.79	31.89

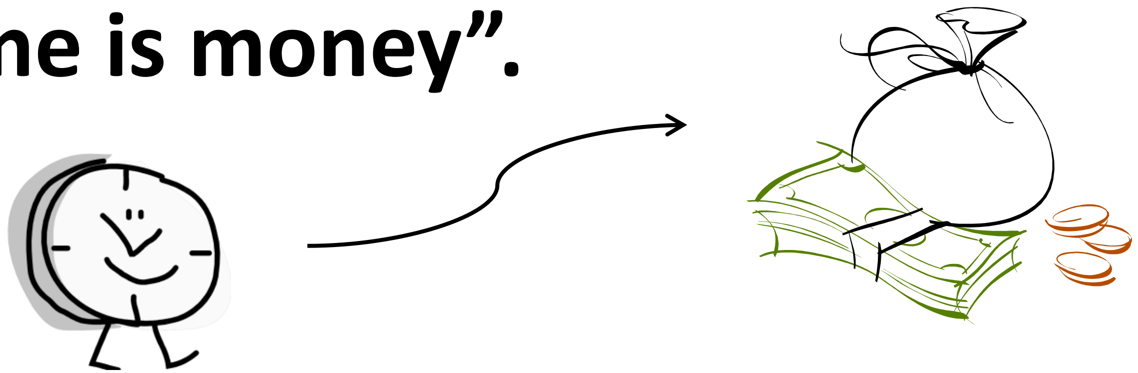
5 Conclusions

- Conclusions based on synthetic data:
  - Many observations are necessary to detect thresholds.
  - HTF and STFs reproduce correct coefficients when thresholds are present (power function not).
  - STF can easily be applied in any estimation tool for discrete choice analysis that can handle non-linear utility functions.
- Observations based on stated choice data:
  - A time threshold between two and three minutes has been detected.

5 Conclusions

- Implications for value of travel time savings:
  - According to the threshold transformation functions the VTTS increases with the size of the time savings.
  - If thresholds are not considered in a CBA the VTTS should be based on the asymptotic value of the threshold models (higher than the VTTS of a linear model).
  - Do not ignore a threshold in the estimation procedure although it might not be included in project appraisal.

We have seen in the previous slides "time is money".



Thank you very much that you have invested in this presentation.