The Value of Travel Time

Insights from British and Danish national studies

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Institute for Transport Studies (ITS)

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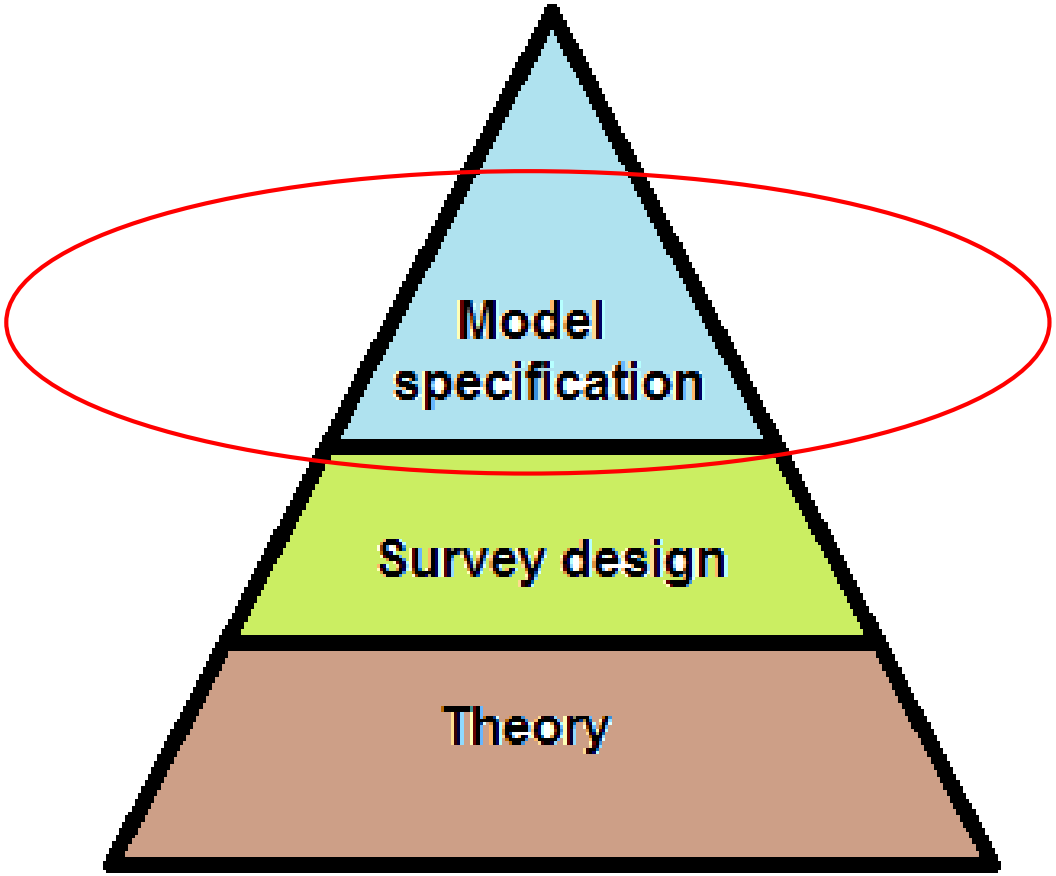
The Value of Travel Time Changes



The Value of Travel Time Changes

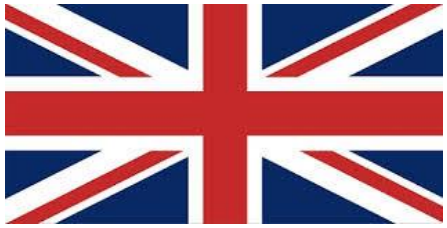
- Focus on national studies
  - **Value of travel time: key input for appraisal of projects**

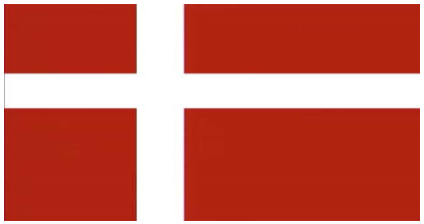
The Value of Travel Time Changes

- Numerous **issues** remain **unresolved.** Are we doing anything wrong? *How can we do things better?*

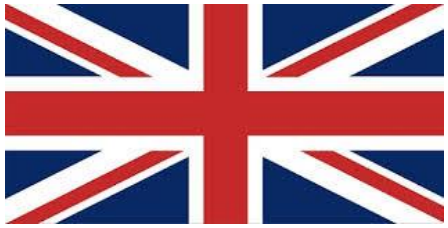
  - Our contribution**:**

    Comparative analysis of some elements **of two important national studies.**

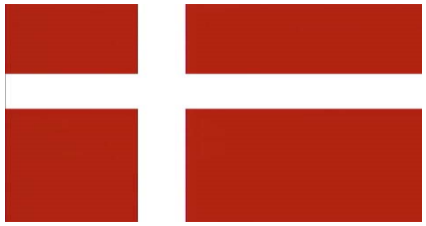




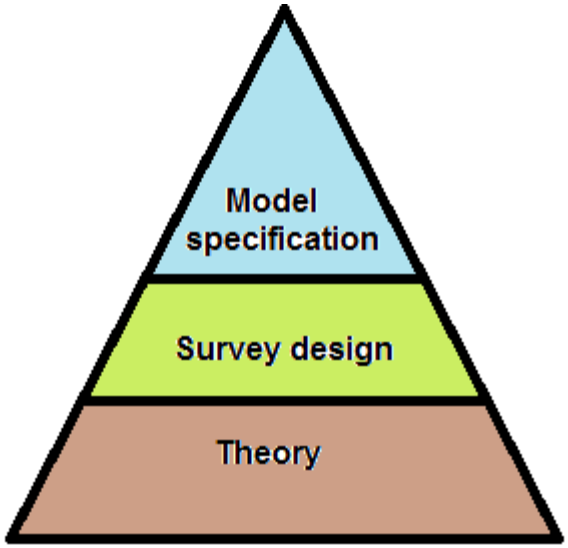
Two national studies on the Value of Time



Vs.



- Why is this analysis interesting?

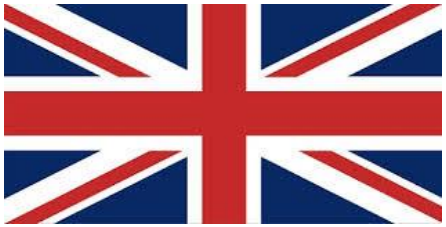


- 0. Travellers & context: Different (potentially)
- 1. Microeconomic theory
- 2. Design: Identical*
- 3. Models: Different

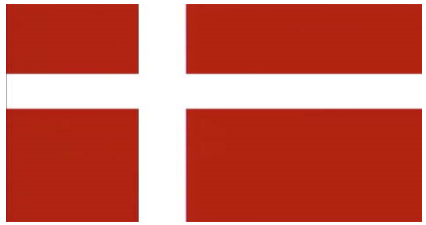
The Value of Travel Time Changes

- Two modelling approaches:

Random Utility



Random Valuation



The Value of Travel Time Changes

- Two modelling approaches:

Random Utility

$$y = 1\{V_1 > V_2 + \varepsilon\}$$

Random Valuation

$$y = 1\{VTTC < \text{BVTTC} + \varepsilon\}$$

Imagine a travel choice scenario such as follows:

	TRAVEL OPTION 1	TRAVEL OPTION 2
COST	£5	£10
TIME	60 min.	30 min.

Implicit valuation threshold:

$$\frac{|10-5|}{|30-60|} * 60 = 10\ £/\text{hour}$$

(known as: Boundary VTTC)

The Value of Travel Time Changes

- Two modelling approaches:

Random Utility

Random Valuation

Related to a particular type of Stated Choice data: 2 options & 2 attributes

This type of data is common in European national studies

The Value of Travel Time Changes

Random Utility

Random Valuation

- Theoretical relationship?

The Value of Travel Time Changes

Random Utility

Random Valuation

- Theoretical relationship:
  - **Both derived from Microeconomic Theory**

$$U_i = (V_i, \varepsilon_i)$$

where: $V_i = \beta_c c_i + \beta_t t_i$

  - $VTTC = \frac{\beta_t}{\beta_c}$
  - **Difference: how is the ε_i introduced?**

The Value of Travel Time Changes

Random Utility

Random Valuation

- Theoretical relationship: Deterministic domain
  - If the slow option 1 is chosen, then VTTC < BVTTC:

$$\beta_t * t_1 + \beta_c * c_1 > \beta_t * t_2 + \beta_c * c_2$$

$$\beta_t * (t_1 - t_2) > -\beta_c * (c_1 - c_2)$$

$$\frac{\beta_t}{\beta_c} < -\frac{(c_1 - c_2)}{(t_1 - t_2)}$$

VTTC < BVTTC

The Value of Travel Time Changes

Random Utility | **Random Valuation**

- Theoretical relationship: Stochastic domain

$$\begin{cases} \widetilde{U_1} = \widehat{\beta_t} * t_1 + \widehat{\beta_c} * c_1 + \widetilde{\varepsilon_1} \\ \widetilde{U_2} = \widehat{\beta_t} * t_2 + \widehat{\beta_c} * c_2 + \widetilde{\varepsilon_2} \end{cases} \quad (1) \quad \Longleftrightarrow \quad \begin{cases} U_1 = \mu * \mathrm{BVTTC} + \varepsilon_1 \\ U_2 = \mu * \mathrm{VTTC} + \varepsilon_2 \end{cases} \quad (2)$$

Where:
ε_i are i.i.d.
μ: scale parameter
$\widehat{\beta_t} = \mu\beta_t$
$\widehat{\beta_c} = \mu\beta_c$

- Rearrange (2):

$$\begin{cases} U_1 = 0 + \varepsilon_1 \\ U_2 = \mu * VTTC - \mu * BVTTC + \varepsilon_2 \end{cases} \quad (3)$$

- Multiply (3) by β_c and Δt :

$$\begin{cases} \Delta t\beta_c U_1 = 0 + \Delta t * \beta_c * \varepsilon_1 \\ \Delta t\beta_c U_2 = \underbrace{\Delta t * \beta_c * \mu * VTTC}_{\mu * \beta_t * \Delta t} - \underbrace{\Delta t * \beta_c * \mu * BVTTC}_{\mu * \beta_c * \Delta c} + \Delta t * \beta_c * \varepsilon_2 \end{cases}$$

The Value of Travel Time Changes

Random Utility

Random Valuation

- Theoretical relationship: Stochastic domain

$$\begin{cases} \widetilde{U_1} = \widehat{\beta_t} * t_1 + \widehat{\beta_c} * c_1 + \widetilde{\varepsilon_1} \\ \widetilde{U_2} = \widehat{\beta_t} * t_2 + \widehat{\beta_c} * c_2 + \widetilde{\varepsilon_2} \end{cases} \Leftrightarrow \begin{cases} U_1 = \mu * \mathrm{BVTTC} + \varepsilon_1 \\ U_2 = \mu * \mathrm{VTTC} + \varepsilon_2 \end{cases}$$

$$\widetilde{\varepsilon_i} = \Delta t * \beta_c * \varepsilon_i$$

Difference: particular form of heteroskedastic errors

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Random Utility

Random Valuation

- Empirical comparison?

The Value of Travel Time Changes

Random Utility

Random Valuation

- Empirical comparison?
  - 1) Linear
  - 2) in Logarithms
    - 3) + observed heterogeneity
    - 4) + random heterogeneity

The Value of Travel Time Changes

Random Utility

Random Valuation

1

$$\begin{cases} U_1 = \beta_c\left(\frac{\beta_t}{\beta_c} * t_1 + c_1\right) + \varepsilon_1 \\ U_2 = \beta_c\left(\frac{\beta_t}{\beta_c} * t_2 + c_2\right) + \varepsilon_2 \end{cases}$$

$$\begin{cases} U_1 = \mu * \mathrm{BVTTC} + \varepsilon_1 \\ U_2 = \mu * VTTC + \varepsilon_2 \end{cases}$$

$$; \ \mathrm{VTTC} = \frac{\beta_t}{\beta_c} = \beta_0$$

2

$$\begin{cases} U_1' = \mu * ln(\mathrm{VTTC} * t1 + c1) + \varepsilon_1' \\ U_2' = \mu * ln(VTTC * t2 + c2) + \varepsilon_2' \end{cases}$$

$$\begin{cases} U_1' = \mu * \ln(\mathrm{BVTTC}) + \varepsilon_1' \\ U_2' = \mu * ln(VTTC) + \varepsilon_2' \end{cases}$$

3

$$\mathrm{VTTC} = e^{\beta_0 + \beta_{BC} \ln\left(\frac{C}{C_0}\right) + \beta_{BT} \ln\left(\frac{T}{T_0}\right) + \beta_I \ln\left(\frac{I}{I_0}\right)} = \beta_0 * \left(\frac{C}{C_0}\right)^{\beta_{BC}} \left(\frac{T}{T_0}\right)^{\beta_{BT}} \left(\frac{I}{I_0}\right)^{\beta_I}$$

4

$$\mathrm{VTTC} = e^{\beta_0 + \beta_{BC} \ln\left(\frac{C}{C_0}\right) + \beta_{BT} \ln\left(\frac{T}{T_0}\right) + \beta_I \ln\left(\frac{I}{I_0}\right) + \boldsymbol{u}}$$

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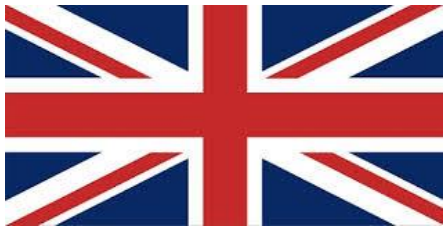
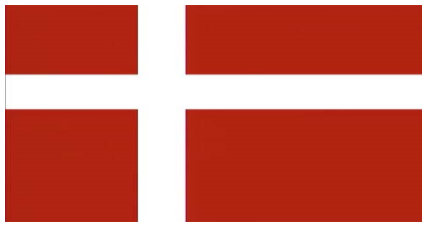
Two national studies on the Value of Time

- **Design & dataset** in each country:
  - *Common SC design, implemented slightly differently:*

- 1. Travellers & context: Different
- 2. Design: Identical*



	TRAVEL OPTION 1	TRAVEL OPTION 2
COST change (Δc)	100 pence	0
TIME change (Δt)	-15 min.	0



	TRAVEL OPTION 1	TRAVEL OPTION 2
COST	400 pence	300 pence
TIME	30 min.	45 min.

(Illustrative values in £, instead of DKK, for comparison)

The Value of Travel Time Changes

	1. Linear				2. Logarithms			
	RU		RV		RU		RV	
	Est.	t-test	Est.	t-test	Est.	t-test	Est.	t-test
β_c	1	na	na	na	1	na	na	na
β_0	4.89	18.64	3.22	11.76	3.71	22.38	2.75	23.71
μ	-0.0138	-20.81	0.115	24.03	-6.42	-23.12	0.79	33.15
VTTC pence/min	4.89		3.22		3.71		2.75	
Obs.	10598		10598		10598		10598	
Parameters	2		2		2		2	
Null LL	-7345.974		-7345.974		-7345.974		-7345.974	
Final LL	-6746.152		-6570.224		-6690.042		-6465.961	
Adj. Rho^2	0.081		0.105		0.089		0.120	

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The Value of Travel Time Changes

	3. Logarithms + Covariates				4. Log + Covariates + Random Het.			
	RU		RV		RU		RV	
	Est.	t-test	Est.	t-test	Est.	t-test	Est.	t-test
β_c	1	na	na	na	1	na	na	na
β_0	1.70	30.23	1.30	28.25	1.58	28.64	1.29	28.11
μ	7.39	25.26	0.859	34.24	11.5	24.06	1.09	33.00
β_{BC}	0.470	8.78	0.431	7.57	0.431	7.45	0.428	25.29
β_{BT}	-0.362	-4.81	-0.196	-2.68	-0.279	-3.50	-0.189	-2.61
β_I	0.273	5.13	0.411	8.06	0.344	6.40	0.382	7.77
σ	na	na	na	na	1.07	21.22	1.11	25.29
VTTC pence/min	5.47		3.67		8.61		6.72	
Obs.	10598		10598		10598		10598	
Parameters	5		5		6		6	
Null LL	-7345.974		-7345.974		-7345.974		-7345.974	
Final LL	-6607.502		-6300.028		-6306.561		-5910.137	
Adj. Rho²	0.100		0.142		0.141		0.195	

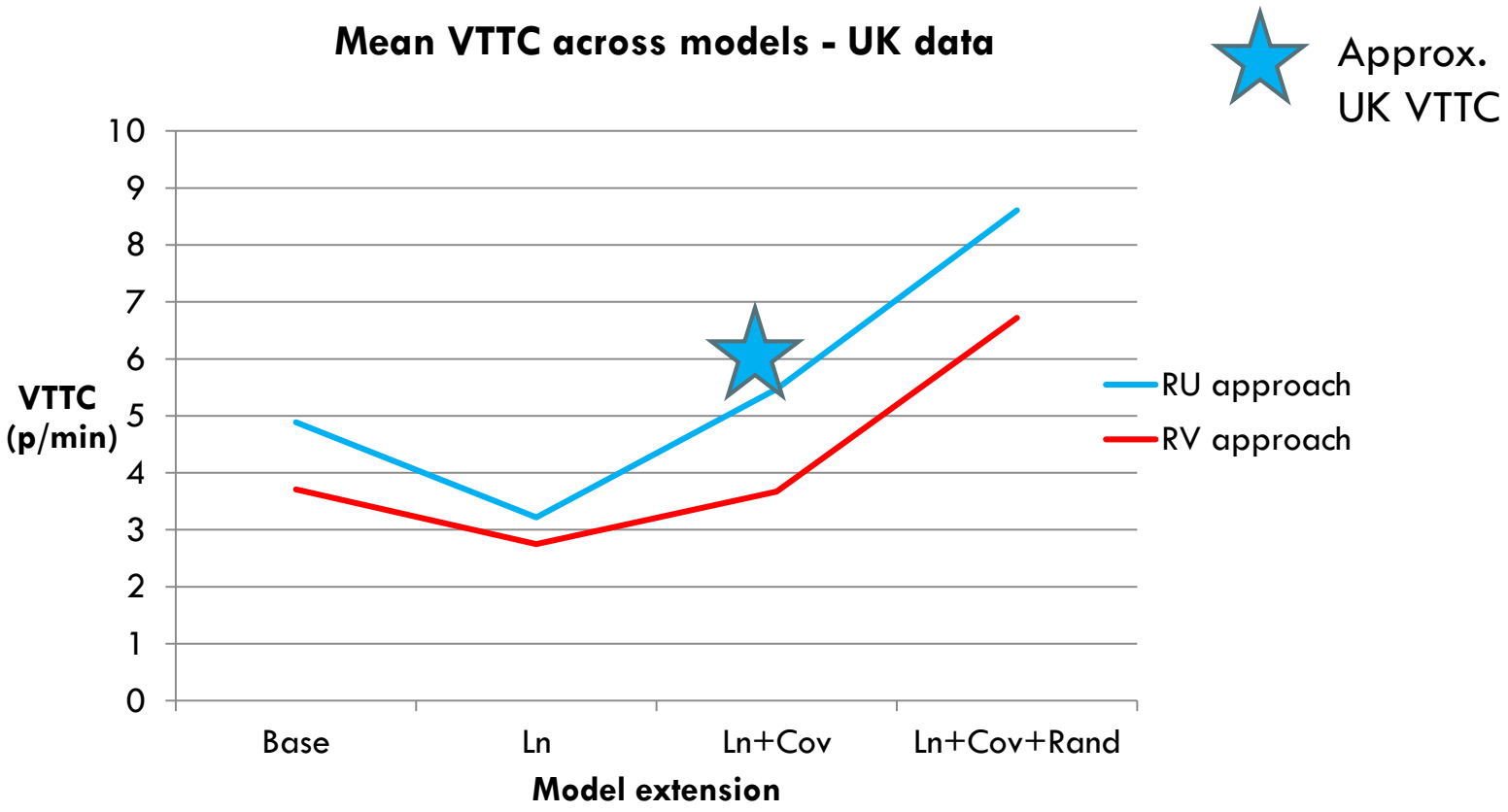
The Value of Travel Time Changes

	1. Linear				2. Logarithms			
	RU		RV		RU		RV	
	Est.	t-test	Est.	t-test	Est.	t-test	Est.	t-test
β_c	1	na	na	na	1	na	na	na
β_0	63.3	14.6	20.5	11.9	31	13.3	31.1	23.91
μ	-0.00058	-14.5	0.0169	28.7	-3.14	-18.47	0.711	35.36
VTTC DKK/hour	37.95		20.5		18.6		18.66	
Obs.	17020		17020		17020		17020	
Parameters	2		2		2		2	
Null LL	-11797.4		-11797.4		-11797.4		-11797.4	
Final LL	-11378.7		-10807.6		-10922.3		-10763.2	
Adj. Rho^2	0.035		0.084		0.074		0.087	

The Value of Travel Time Changes

	3. Logarithms + Covariates				4. Log + Covariates + Random Het.			
	RU		RV		RU		RV	
	Est.	t-test	Est.	t-test	Est.	t-test	Est.	t-test
β_c	1	na	na	na	1	na	na	na
β_0	4.33	62.25	3.89	87.25	4.12	68.27	3.89	84.77
μ	4.41	20.37	0.768	36.3	10.3	24.4	1.06	34.84
β_{BC}	0.571	6.51	0.701	9.44	0.581	7.00	0.705	9.23
β_{BT}	-0.48	-3.87	-0.643	-6.06	-0.451	-3.67	-0.633	-5.77
β_I	0.501	6.63	0.638	9.76	0.611	8.47	0.633	9.74
σ	na	na	na	na	1.49	26.8	1.47	30.21
VTTC DKK/hour	**45.57**		**29.35**		**112.08**		**86.45**	
Obs.	17020		17020		17020		17020	
Parameters	5		5		6		6	
Null LL	-11797.4		-11797.4		-11797.4		-11797.4	
Final LL	-10748.8		-10313.8		-9690.48		-9185.81	
Adj. Rho²	0.088		0.125		0.178		0.221	

The Value of Travel Time Changes



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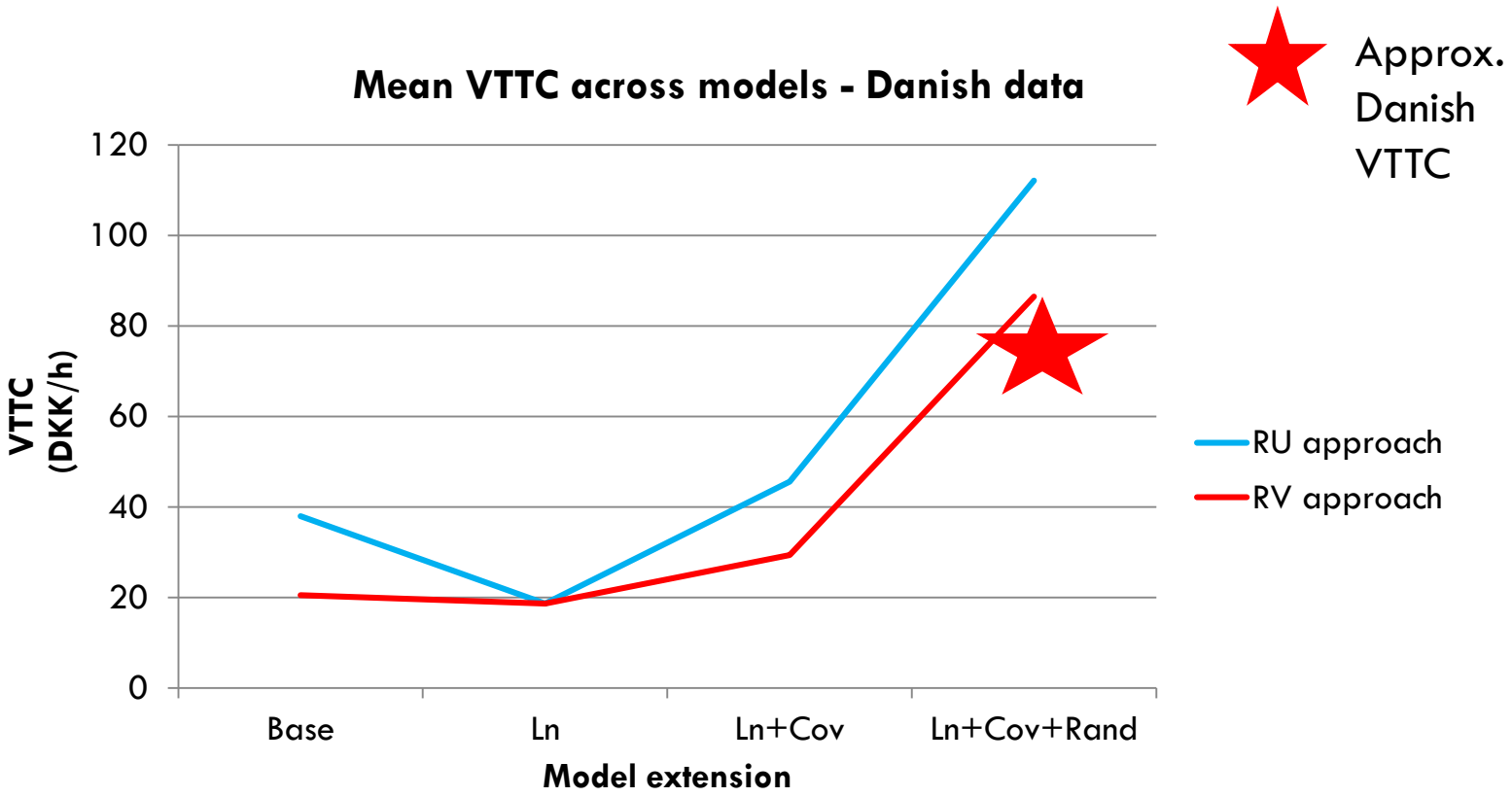
The Value of Travel Time Changes



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The Value of Travel Time Changes

- Some results:
  - **The choice of approach matters.**
  - Theoretically, none of the approaches is preferred.
  - Empirically:
    - RandomValuation > RandomUtility (model fit)
    - Lower *Value of Time* using RV approach
    - Similar pattern across models in UK & Denmark

The Value of Travel Time Changes

- Some issues and recommendations:
  - **Risk of significant biases** on VTTC depending on the form of error heteroskedasticity selected.
  - **RV preferred** if feasible: e.g. with simple 2options&2attributes experiments.
  - **RU** approach: likely to have heteroskedastic errors that **need correction**.
  - Test both linear and logs specifications.

The Value of Travel Time Changes

- Some questions:
  - **Why is the VTTC always lower** with the RV approach?
  - **Validity of** results using **Random Utility** approach? Always worse model fit.
  - Why are **individuals' preferences so similar in two different countries**? What is the role of stated choice **design** on results?

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Thanks

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