Building efficient stated choice design for departure time choices using the scheduling model

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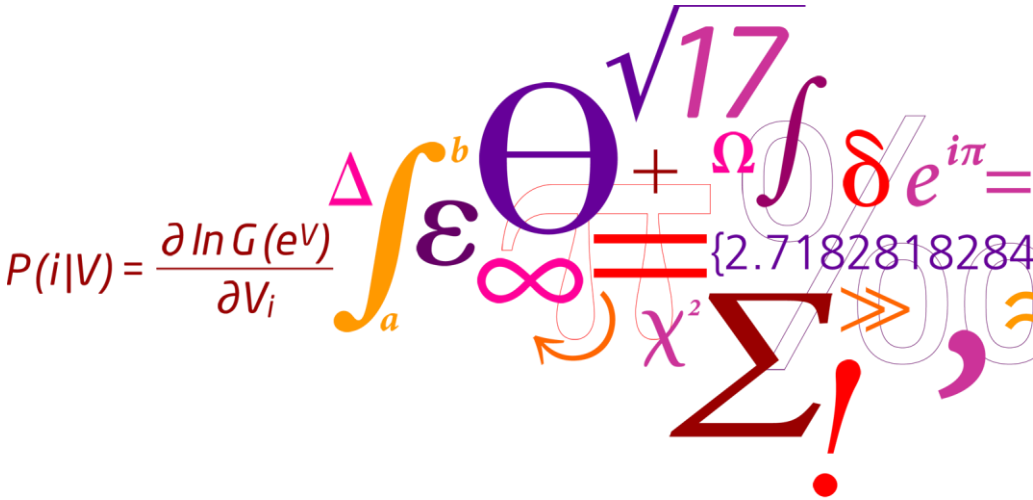

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Agenda

- Introduction and objective
- The Scheduling Model
- Experimental design & data collection
- Findings & perspectives

Introduction

Departure time is especially important because of congestion. Studies have shown that:

- People are more likely to change their departure time to address the problem of congestion rather than changing mode (e.g. Hendrickson & Planke, 1984, SACTRA, 1994, Kroes et al., 1996, Hess et al., 2007).

Literature

- The basic concept: the **Scheduling Model** (SM) by Small, 1982 (Small et al., 1995, de Jong et al, 2003, Hess et al., 2007a, Hess et al., 2007b, Börjesson, 2008b)
- Congestion leads to **Travel Time Variability** (TTV). TTV is an important aspect in departure time models (e.g. Small et al, 1995, Börjesson, 2006, Börjesson, 2008a, Fosgerau et al., 2008, Koster & Verhoef, 2012, Arellana et al., 2012).
- Studies have included flexibility, but only in terms of **fixed or flexible working hours**. (de Jong et al, 2003, Hess et al., 2007a, Hess et al., 2007b, Börjesson, 2008a)
- Arellana et al., 2012 is the only study that have included **attitude** in departure time choices.

Objectives

We believe that the research of departure time can be improved through in depth analysis of:

Customized data collection:

- explore the possibility of building an **efficient stated preference (SP) design** for departure time choice.

Modelling:

- explore in detail the effect of flexibility in the departure time choice
- explicitly account for a full Theory of Plan Behavior (TPB), not only attitudes

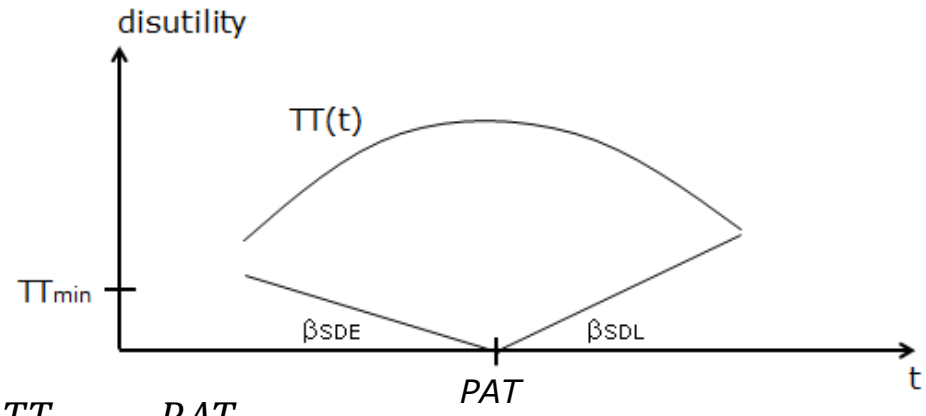
The Scheduling Model

The scheduling model was first formulated by Small (1982):

$$V_{jnt} = \beta_{TT} \cdot E(TT_{jnt}) + \beta_{TC} \cdot TC_{jnt} + \beta_{SDE} \cdot E(SDE_{jnt}) + \beta_{SDL} \cdot E(SDL_{jnt})$$

Where:

$$E(TT_{jnt}) = \sum_{i=1}^{I} p_i \cdot TT_{jnti}$$
$$E(SDE_{jnt}) = \sum_{i=1}^{I} p_i \cdot SDE_{jnti}$$
$$E(SDL_{jnt}) = \sum_{i=1}^{I} p_i \cdot SDL_{jnti}$$
$$SDE_{jnti} = \max(-SD_{jnti}; 0)$$
$$SDL_{jnti} = \max(0; SD_{jnti})$$
$$SD_{jnti} = AT_{jnti} - PAT = DT_{jnti} + TT_{jnti} - PAT$$



Experimental design

Attributes and levels

The efficient design contains:

- 3 alternatives (early, same, later)

- 4 attributes (Dep. Time, TT, TC, TTV) for each alternative

- 3 levels for each attribute, except TC which have 4 levels

– Travel Time Variability was included as an additional TT experienced once a week as done by Arellana et al. (2012)
– Efficient design was created using the software package Ngene.

Experimental design

Challenge 1: Realistic choice set

- In order to obtain realism we created customized choice situations with respect to the reported trip in the trip diary.
- In efficient designs we need to know the characteristics (i.e. TT, dep. time and PAT) of the trips (which we don't have) before we can generate the SC-design, so we define different classes based on 10 minutes intervals.

- Problem: We need to build 238 SC-designs!
- Solution: Generate the choice set from the PAT, which allow for a generic design across TT
  - 6 different SC-designs (TT=10, 20, 30, 40, 50, and 60 min)

Experimental design

Challenge 2: PAT outside rush-hours

- Problem: If a person have a PAT outside rush hours then there is no point to reschedule the trip.
- Solution: We narrow the time period of investigation so we could assume TT distribution is uniform within this period.
  - We have defined the time period to be between 7:00-9:00.

Experimental design

Challenge 3: Design variables and model variables

– Design variables and model variables is not a simple or 1-to-1 relation.

$$V_{jnt} = \beta_{TT} \cdot E(TT_{jnt}) + \beta_{TC} \cdot TC_{jnt} + \beta_{SDE} \cdot E(SDE_{jnt}) + \beta_{SDL} \cdot E(SDL_{jnt})$$

Design attributes	Model attributes
Travel time	Expected travel time
Travel cost	Travel cost
Departure time	Expected schedule delay early
Reliability	Expected schedule delay late

attributes which are shown to the respondents

Prior parameters

Prior parameters are nessecary in order to build effecient designs

1) A meta analysis reported in Börjesson (2008) was used, in order to maintain the same ratio between the parameters for TT and SDE/SDL.
2) With these priors we simulated appr. 18000 choices assuming people choose according to the scheduling model plus an EV1 error term
3) The prior parameters could be recuperated during the design phase when estimating simulated choices.

Data collection

Structure of questionnaire:

1. Introduction
2. Full trip diary of a 24-hour period
3. Specific questions about activity/trip reschedule flexibility
4. Stated Preference experiment
5. Theory of Plan Behavior questions
6. Socio-demographic information about the respondent

https://www.tu2013.dk/mt_v3/start.php

Data collection

1. Introduction

The introduction contains a brief description of the survey and the following initial questions needed to customize the trip diary and SC experiment:

1. Where do you live?
2. What is your main occupation?
3. Where do you work?
4. What is your intended arrival time at work ("yesterday")?
5. In order to be at work at this time, when do you need to depart from home?

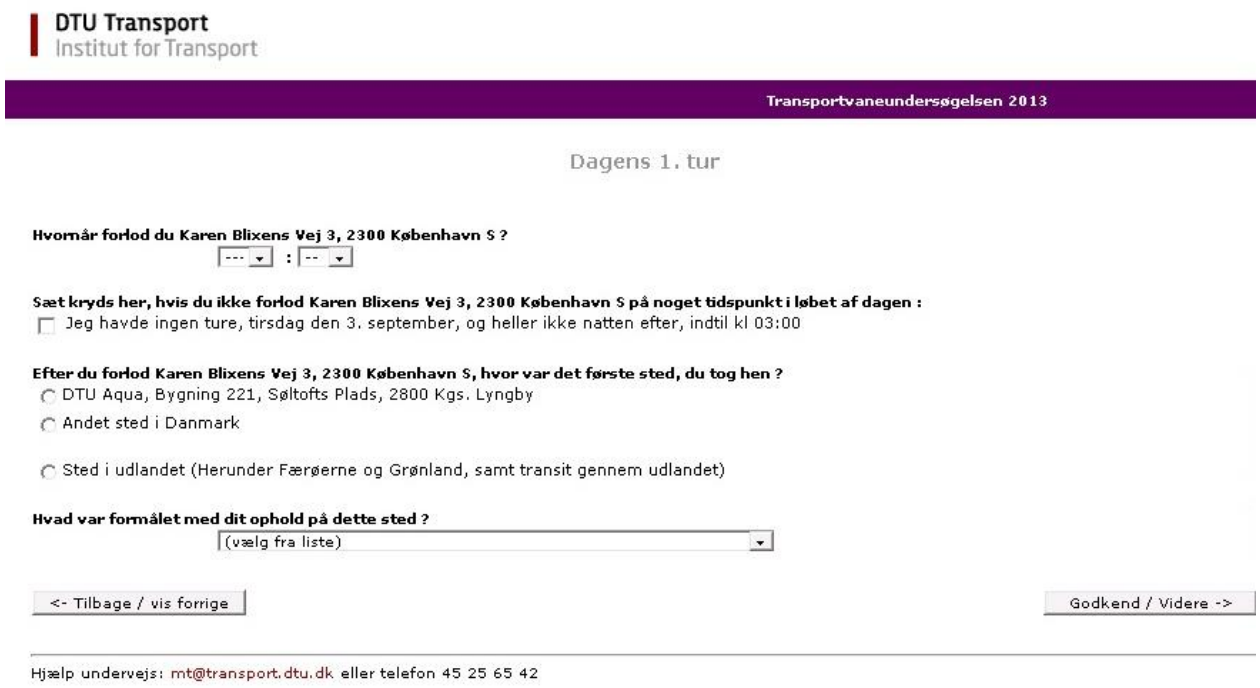
Data collection

2. Trip diary

The trip diary was built based on the Danish National Travel Survey as it is a highly detailed survey and already thoroughly tested.

A full trip diary of a 24-hour period (starting and ending at 3 a.m.)

Example:



Data collection

3. Activity reschedule flexibility

Example:

Vi stiller her nogle uddybende spørgsmål om dine alternative muligheder for din tur fra Haraldsgade 62, 2100 København Ø til Rosenborg Børnehave

Var der nogen begrænsninger for, hvor tidligt du kunne tage af sted?

○ Ja ○ Nej, jeg kunne frit vælge hvornår jeg tog af sted

Skulle du være fremme på din destination til et bestemt tidspunkt?

○ Ja ○ Nej, jeg kunne frit vælge hvornår jeg var fremme

Kunne du selv vælge hvornår du tog afsted?

(vælg fra liste) ▼

Hvor ofte foretager du denne tur?

(vælg fra liste) ▼

Vi ser nu på formålet ved dit rejsemål (Rosenborg Børnehave/fritidshjem, Rosenvængets Allé 28, 2100 København Ø)

Kunne du helt have udeladt denne aktivitet?

○ Ja ○ Nej

Kunne du have udført denne aktivitet et andet sted?

○ Ja ○ Nej

Kunne en anden person have udført denne aktivitet for dig?

○ Ja ○ Nej

Kunne du have udført denne aktivitet på en anden dag?

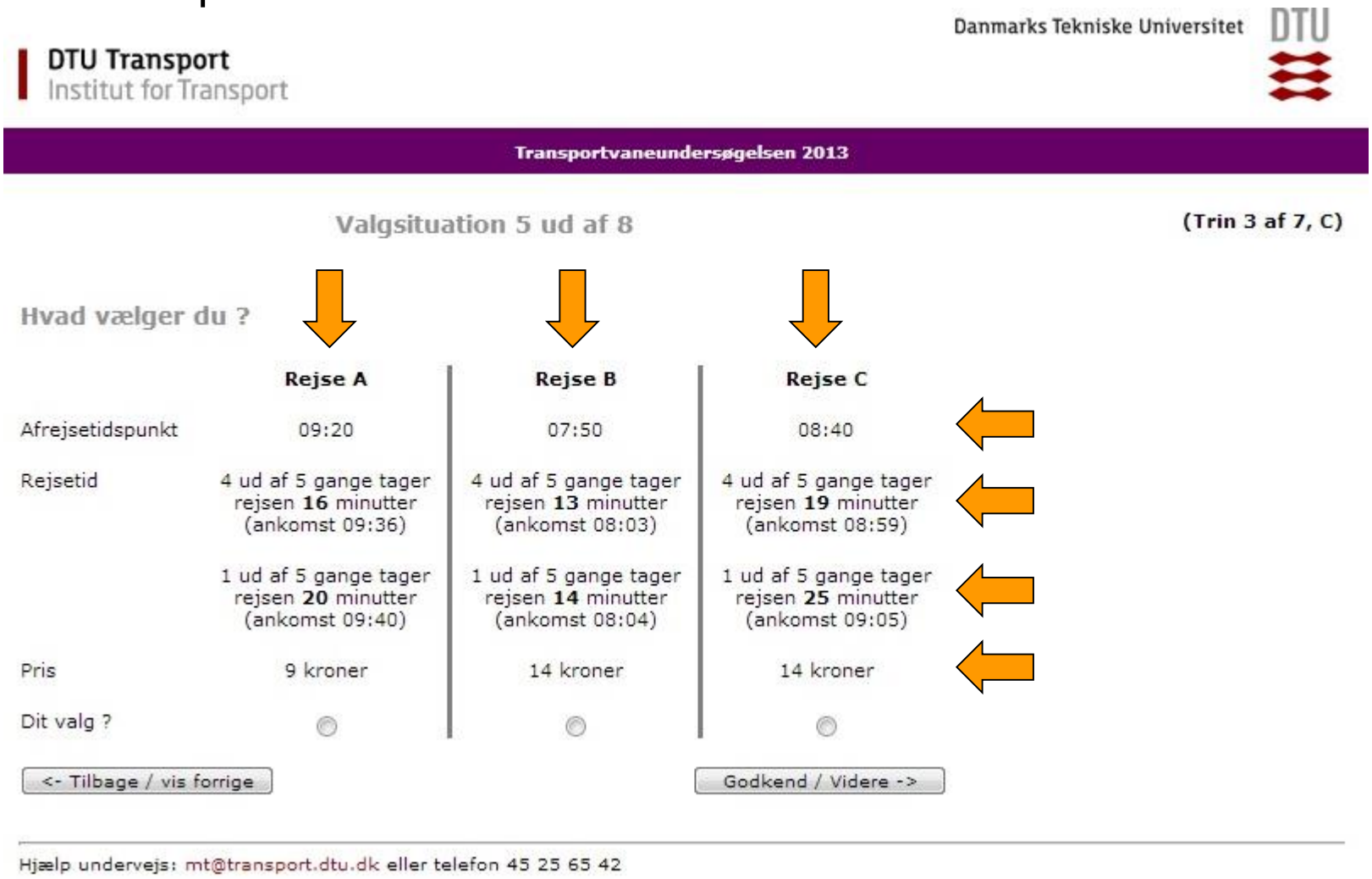
○ Ja ○ Nej

Kunne du have udført denne aktivitet på et andet tidspunkt af dagen?

○ Ja ○ Nej

Data collection

4. Example of SP choice task



Data collection

5. TPB questions

We collected not only attitudes but the full TPB. We aim to test the following latent construct:

- **Attitude towards being on time,** e.g. *"It is very important for me to be on time at work"*
- **Attitude towards flexibility in departure times**, e.g. *"I am willing to change my working hours in order to travel outside rush hours"*
- **Attitude towards low travel time**, e.g. *"It is very important for me to have a short travel time to/from my working place"*
- **Subjective norm (SN)**, e.g. *"My colleagues think I should arrive on time at work"*
- **Personal norm (PN)**, e.g. *"I feel obliged to be at work on time"*
- **Perceived behavioral control (PBC)**, e.g. *"It is difficult for me to be at work on time"*
- **Perceived mobility necessities (PMN)**, e.g. *"I require a high level of mobility to organize my daily activities"*
- **Intention (Int)**, e.g. *"I plan to be at work on time in the near future"*

Data collection

6. SE questions

We included the following SE questions (in addition to home and work location):

- **For all HH-members:** age, sex, income, HH-relation (e.g. dad), drivers license.
- **For primary respondents:** education, occupation, work location, have bike and/or season ticket, parking facilities at work, working hours per week, fixed/flexible working hours (if fixed working hours: work start and end time), work from home (number of days within the last month).
- **For HH**: Number of cars available, parking facilities at HH.

Data

Variable	Value	Percent
Gender	Male	48.4
	Female	51.6
Age	18-29	4.4
	30-39	19.6
	40-49	26.5
	50-59	33.5
	60-69	15.3
	70+	0.7
Education	Non-university	5.1
	University	94.9
Work Type	Fixed	31.6
	Flex	65.5
	Unknown	2.9
Resp income [1000 DDK]	0-99	2.2
	100-199	1.1
	200-299	2.9
	300-399	16.4
	400-499	18.2
	500-599	15.3
	600-699	8.7
	700-799	7.6
	800-899	6.5
	900-999	4.4
	1000 or more	5.8
	Unknown	10.9

Model estimation

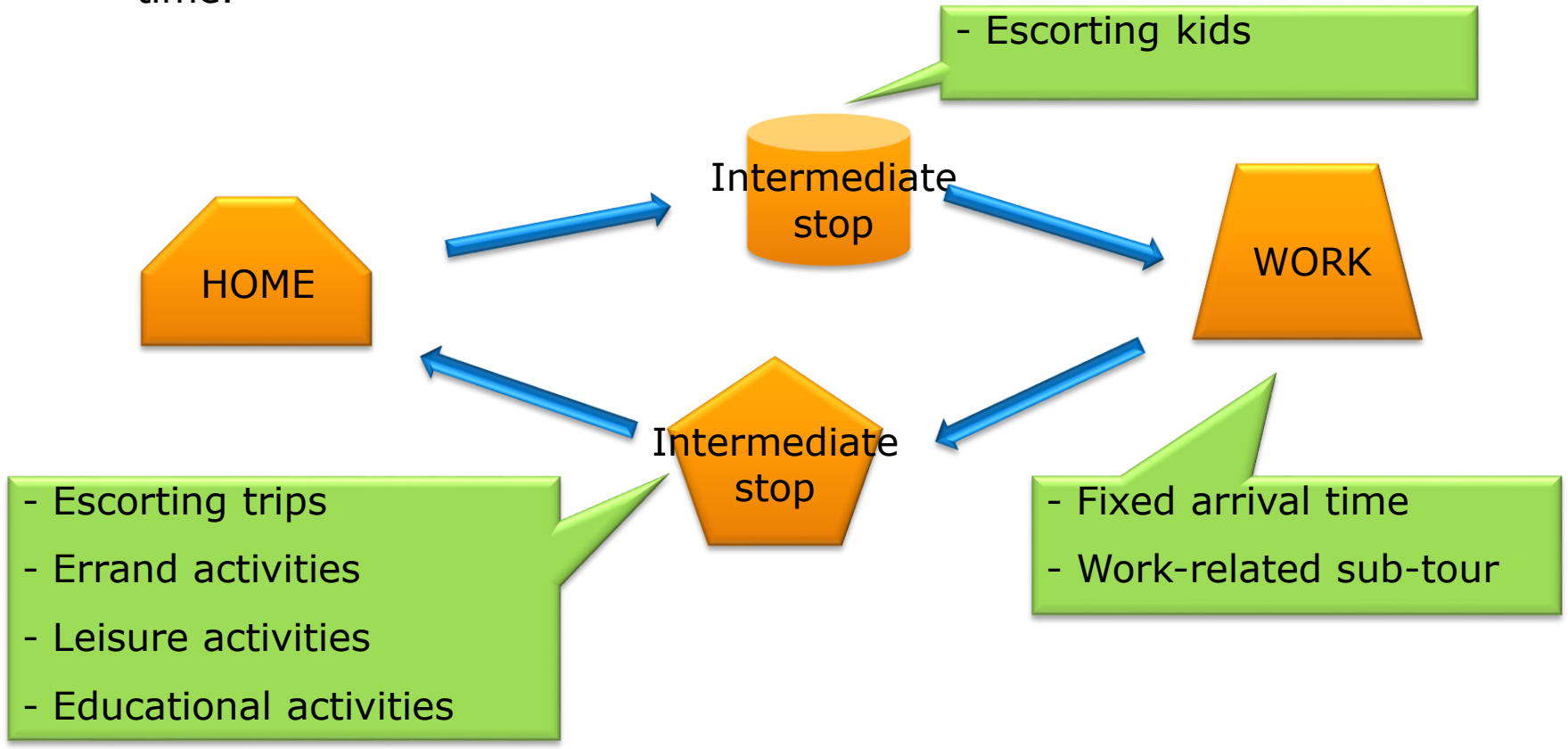
Basic scheduling model

	MNL	
Name	Value	Robust t-test
ASC2	0.29	1.32
ASC3	0.12	0.57
ETT	-0.0965	-9.23
TC	-0.0709	-7.39
ESDE	-0.0285	-6.29
ESDL	-0.0538	-11.06

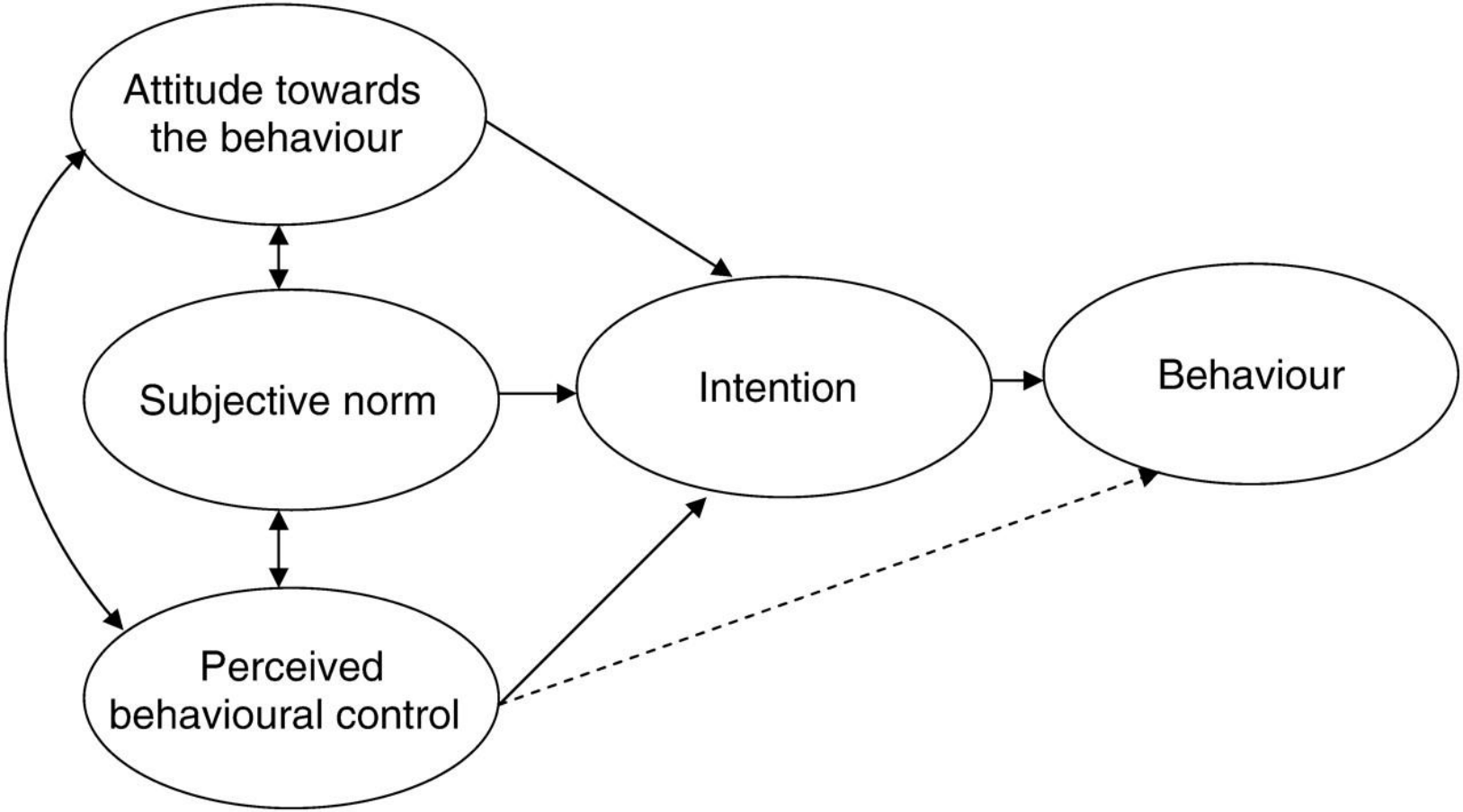
- **SDL<SDE<0**, which is as expected (Small, 1982, Hendrickson & Planke, 1984, Small et al., 1995, de Jong et al., 2003, Hess et al., 2007a, Hess et al., 2007b, Börjesson, 2007, Börjesson, 2008a, Asensio & Matas, 2008, Koster, Kroes & Verhoef, 2011, Arellana et al., 2012)

Model flexibility

- Investigate in depth how flexibility (or lack of same) affects departure time.



Theory of Planned Behavior



Summary

- Efficient stated choice design was created
- Data was collected specifically to capture
  - Detailed level of information about individual flexibility
  - A set of latent variables according to the theory of planned behaviour

Thank you for your attention!