# Theory Driven Evidence based policy in the Transport sector

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# MIMIC- Model

- Some frame works, for instance that of Muthén (1984), include an extra $\Gamma x_{1j}$ for regressions of latent variables on observed covariates:

$$\eta_j = \alpha + \mathbf{B}\eta_j + \mathbf{\Gamma}\mathbf{x}_{1j} + \zeta_j,$$

- Where $\alpha$ is an intercept vector. Muthén specifies the model conditional on the covariates so that distributional assumptions are not required for the covariates.

- In the measurement model, the additonal term $\mathrm{K}x_{2j}$ is included by Muthén and Muthén (1998) to represent regressions of observed responses on observed covariates.

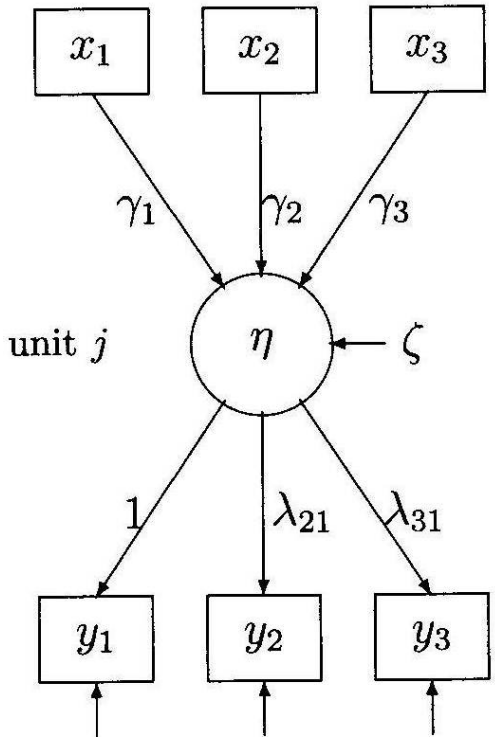
$$\mathbf{y}_j = \boldsymbol{\nu} + \boldsymbol{\Lambda}\boldsymbol{\eta}_j + \mathbf{K}\mathbf{x}_{2j} + \boldsymbol{\epsilon}_j,$$

- Where $\upsilon$ is a vector of intercepts (often $x_{1j} = x_{2j}$).

- A popular structural equation model with observed covariates is the Multiple-Indicator Multiple-Cause (MIMIC) model, a one-factor model where the factor is measured by multiple indicators and regressed on serveral observed covariates or “causes“ (e.g. Zellner, 1970; Hauser and Goldberger, 1971; Goldberger, 1972). Here the structural model is simply:

$$\eta_j = \alpha + \boldsymbol{\gamma}' \mathbf{x}_{1j} + \zeta_j .$$

- A path diagram of a MIMIC model with three indcators and three covariates:



Study 1 :
An observational study in Austria (Institute of Transportation Research, BOKU Vienna) based on Hössinger/Schmidt 2010

# Description of variables and their means

- The data were provided by 229 interactive interviews and a preceding written survey. The sample includes six stakeholder groups as described in Table 2-3. Table 5-1 lists all observed variables used in the following causal models.
- The presumed key predictors, i.e., the estimates and values of the effects of the policy as well as the estimated approval rates, are listed entirely in the table, even those that didn't qualify for the model. The left column groups the variables by several categories. The personal characteristics are grouped according to the Situational Approach. Regarding the beliefs associated with the transport policy, the grouping follows the Theory of Planned Behavior.
- The middle column shows the labels used in SEM, and the right column indicates how the variables were measured. Attitudes (judgement of…) and validations (validation of…) were throughout measured on a six point Likert rating scale from 'full rejection' or 'fully unimportant' to 'full approval' or 'fully important'. The scores were then transferred into percentage of approval or importance as described in Figure 2-1.

# Description of variables and their means

- Table 5-2 shows the mean values of the variables for the total sample and also for the different stakeholders. The emphasis of this study is on policy makers. They form the main part of the sample and act as reference.
- For the five remaining groups, a variable-by-variable comparison with the policy makers was performed, using a one-factorial analysis of variance with post-hoc comparison of means and Bonferroni correction. Significant deviations are marked with ** ($P <= 0.01$) or * ($0.01 < P <= 0.05$).
- Due to the small sample, only few deviations reach the level of significance. They apply throughout to the citizens and commercial representatives, as these are the largest groups aside from policy makers.

# List of variables and their indicators used in SEM

| Category | Label in SEM | Indicator and kind of measurement |
|---|---|---|
| Objective situation | rep. of commerce | Dummy variable to distinguish representatives of commerce (1) from other respondents (0) |
| | citizens | Dummy variable to distinguish citizens selected at random (1) from other respondents (0), which were selected systematically |
| | gender | Females (0); males (1) |
| | number of PT trips | Number of days during the last calendar week (Monday to Friday) where a public means of transport was used for private or professional trips |
| | number of car trips | Number of days during the last calendar week (Monday to Friday) where a car was used for private or professional trips |
| Personal values | individual freedom | Judgement of the statement "Life in Austria is too much regulated, people should be given more freedom" |
| | merit principle | Judgement of the statement "The job performance should be more awarded in Austria in order to increase the competitiveness of Austrian's economy" |
| | support for the poor | Judgement of the statement "People living in poverty should receive more support from the state, even those who are responsible on their own. |
| | concern climate | Judgement of the risk of a large scale environmental damage due to a climate change caused by CO2 emissions |
| | concern nat resources | Judgement of the risk of a large scale environmental damage due to the excessive consumption of non-renewable resources |
| | concern landscape | Judgement of the risk of a large scale environmental damage due to the destruction of natural landscapes |
| Transport policy aims | reduce to needful trips | Judgement of the statement "The car traffic in Austria should be limited to its necessary extent in order to reduce noise and exhaust emissions" |
| | restrict private car use | Judgement of the statement "The use of private cars should be restricted by means of appropriate measures in order to reduce the car traffic in Austria" |

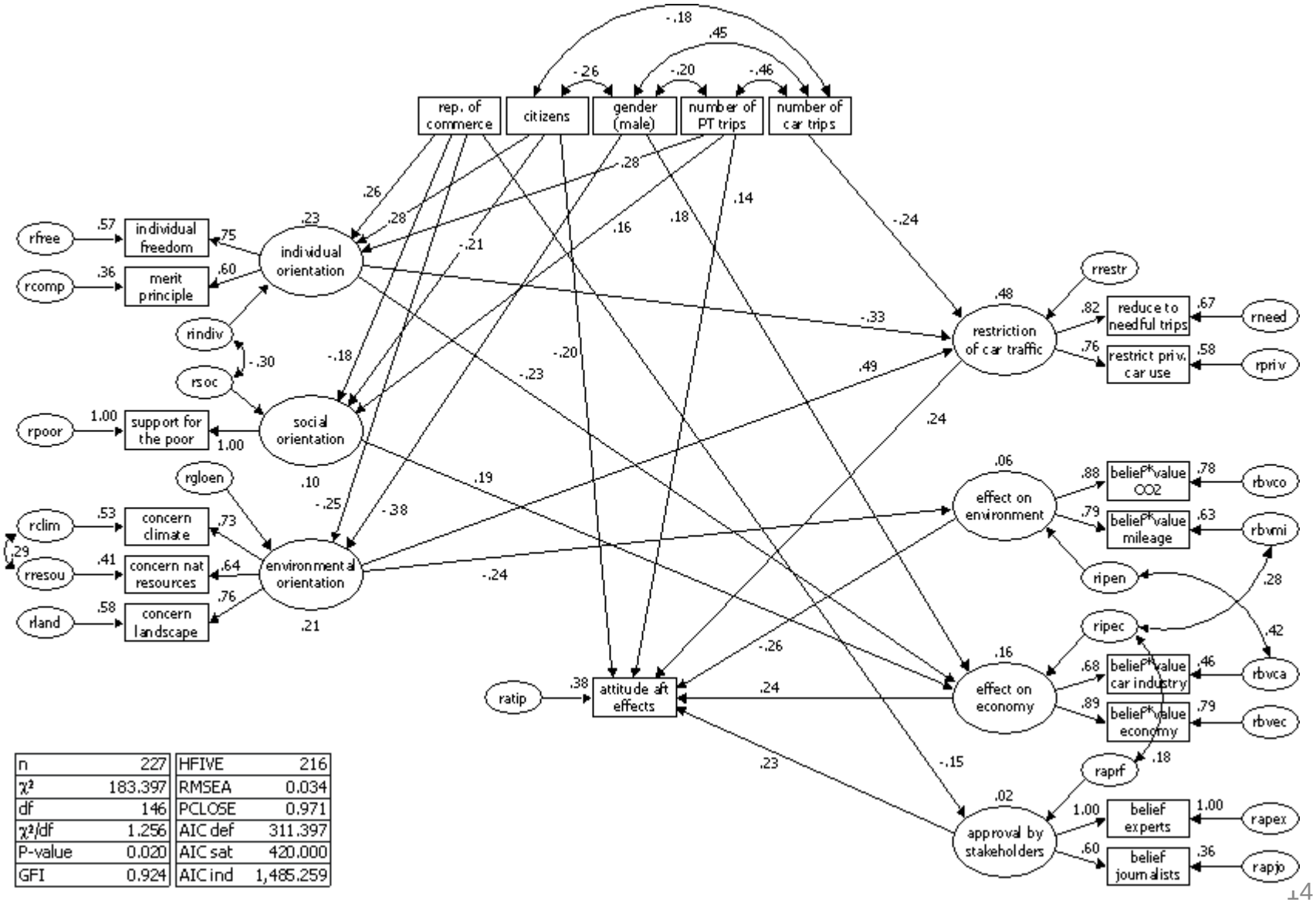
# List of variables and their indicators used in SEM (continued)

| Category | Label in SEM | Indicator and kind of measurement |
|---|---|---|
| Estimation of effects of the policy | belief mileage | Estimation of the effect of a fuel tax increase on the average annual mileage of the car traffic (in % compared to non-implementation) |
| | belief CO2 | Estimation of the effect of a fuel tax increase on the CO2 emissions of the car traffic (in % compared to non-implementation) |
| | belief accidents | Estimation of the effect of a fuel tax increase on insured and killed children on the roads (in % compared to non-implementation) |
| | belief car industry | Estimation of the effect of a fuel tax increase on the performance of the automotive industry (in % compared to non-implementation) |
| | belief economy | Estimation of the effect of a fuel tax increase on the performance of the overall Austrian economy (in % compared to non-implementation) |
| | belief unemplmt | Estimation of the effect of a fuel tax increase on the unemployment rate (in % compared to non-implementation) |
| | belief living stand | Estimation of the effect of a fuel tax increase on the living standard of people with low income (in % compared to non-implementation) |
| | belief elections | Estimation of the effect of a fuel tax increase on the gain or loss of votes of the governing party (in % compared to non-implementation) |
| Validation of effects of the policy | value mileage | Validation of the effect on the average annual mileage |
| | value CO2 | Validation of the effect on the CO2 emissions |
| | value accidents | Validation of the effect on insured and killed children on the roads |
| | value car industry | Validation of the effect on the performance of the automotive industry |
| | value economy | Validation of the effect on the performance of the overall Austrian economy |
| | value unemplmt | Validation of the effect on the unemployment rate |
| | value living stand | Validation of the effect on the living standard of people with low income |
| | value elections | Validation of the effect on the gain or loss of votes of the governing party |
| Estimation of approval to the policy | belief citizens | Estimation of the approval rate of a fuel tax increase in the total population (in %) |
| | belief experts | Estimation of the approval rate of a fuel tax increase by transport experts (in %) |
| | belief journalists | Estimation of the approval rate of a fuel tax increase by journalists (in %) |
| | belief lobbyists | Estimation of the approval rate of a fuel tax increase by representatives of commerce (in %) |
| Transport policy | attitude at beginning | Judgement of the fuel tax increase at the beginning of the interview |
| | attitude aft effects | Judgement of the fuel tax increase after estimation and validation of the effects and occupation with the provided forecast values |
| | attitude aft opinion poll | Judgement of the fuel tax increase after estimation of approval rates of stakeholders and occupation with the provided data of an opinion poll |

Sample means
of the variables used
in SEM in different
stakeholder groups

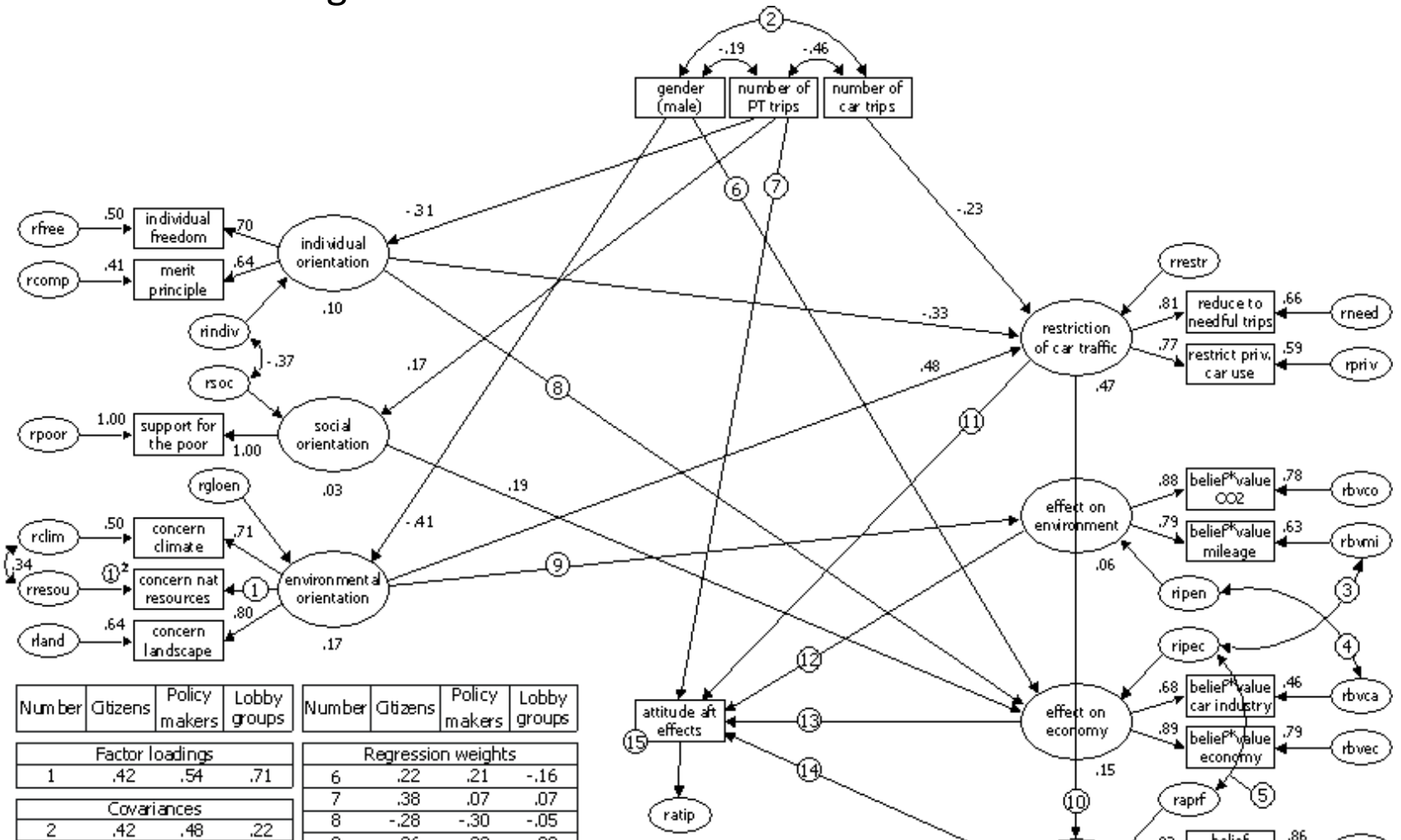
| Category | Label in SEM | Total | policy makers | citizens | representatives of... | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | commerce | employ-ees | car drivers | public transport |
| Sample size | | 229 | 116 | 62 | 20 | 11 | 12 | 8 |
| Objective situation | rep. of commerce (dmy.) | 0.09 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 |
| | citizens (dummy) | 0.27 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | gender (dummy) | 0.73 | 0.77 | 0.55* | 0.94 | 0.82 | 0.83 | 0.88 |
| | number of PT trips (0-7) | 2.31 | 2.35 | 2.21 | 2.20 | 2.00 | 2.17 | 3.43 |
| | number of car trips (0-7) | 2.85 | 3.07 | 2.26 | 3.45 | 3.18 | 2.83 | 2.29 |
| Personal values | individual freedom | 64.10 | 58.28 | 74.52** | 79.00* | 43.64 | 61.67 | 62.50 |
| | merit principle | 77.77 | 77.48 | 79.35 | 86.00 | 63.64 | 78.33 | 67.50 |
| | support for the poor | 63.72 | 69.91 | 55.41* | 51.00 | 74.00 | 63.33 | 57.50 |
| | concern climate | 79.48 | 81.72 | 85.48 | 58.00** | 72.73 | 70.00 | 77.50 |
| | concern nat resources | 75.46 | 75.69 | 83.87 | 57.00* | 76.36 | 63.33 | 70.00 |
| | concern landscape | 78.08 | 77.24 | 86.45 | 65.00 | 78.18 | 71.67 | 67.50 |
| Transport policy aims | reduce to needful trips | 62.82 | 65.00 | 68.33 | 38.00** | 58.18 | 56.67 | 67.50 |
| | restrict private car use | 43.00 | 45.61 | 44.84 | 24.00 | 47.27 | 26.67 | 57.50 |
| Estimation of effects of the policy | belief milage (%) | -5.51 | -4.46 | -9.21 | -3.10 | -4.55 | -4.67 | -1.00 |
| | belief CO2 (%) | -7.98 | -7.54 | -10.20 | -6.50 | -8.45 | -4.58 | -5.00 |
| | belief accidents (%) | -5.52 | -6.03 | -5.34 | -4.74 | -4.73 | -4.83 | -4.00 |
| | belief car industry (%) | -3.67 | -2.36 | -6.95 | -2.50 | -5.00 | -5.36 | 4.13 |
| | belief economy (%) | 2.21 | 4.06 | -2.64** | 1.90 | 6.18 | 1.83 | 9.00 |
| | belief unemplmt (%) | -1.19 | -2.00 | 0.67 | -0.90 | -4.00 | -1.08 | -0.88 |
| | belief living stand (%) | -2.50 | -1.58 | -3.54 | -4.85 | -3.45 | -3.00 | 0.38 |
| | belief elections (%) | -9.07 | -7.32 | -10.39 | -13.26 | -9.73 | -12.83 | -6.63 |
| Validation of effects of the policy | value milage | 66.18 | 68.47 | 64.83 | 55.29 | 61.82 | 68.33 | 70.00 |
| | value CO2 | 78.62 | 80.73 | 80.00 | 69.41 | 78.18 | 68.33 | 75.00 |
| | value accidents | 81.31 | 84.77 | 78.97 | 78.82 | 78.18 | 71.67 | 74.29 |
| | value car industry | 53.64 | 54.16 | 52.20 | 61.11 | 47.27 | 49.09 | 55.00 |
| | value economy | 63.47 | 64.07 | 61.03 | 75.29 | 61.82 | 53.33 | 65.00 |
| | value unemplmt | 68.98 | 74.29 | 64.64 | 64.71 | 69.09 | 58.33 | 50.00 |
| | value living stand | 74.89 | 78.75 | 73.79 | 72.22 | 70.91 | 73.33 | 42.50** |
| | value elections | 47.27 | 56.88 | 36.30** | 30.00* | 48.00 | 45.00 | 27.50 |
| Estimation of approval to the policy | belief citizens (%) | 29.68 | 29.78 | 30.95 | 26.45 | 30.45 | 25.75 | 31.13 |
| | belief experts (%) | 50.96 | 53.01 | 50.31 | 41.35 | 51.00 | 44.33 | 60.25 |
| | belief journalists (%) | 40.47 | 42.00 | 38.29 | 42.10 | 40.20 | 33.83 | 41.50 |
| | belief lobbyists (%) | 25.82 | 25.05 | 31.71 | 13.15 | 22.36 | 25.67 | 27.88 |
| Transport policy | attitude at beginning | 59.39 | 67.93 | 40.32** | 66.32 | 63.64 | 55.00 | 67.50 |
| | attitude aft effects | 59.10 | 67.89 | 48.14** | 43.16* | 60.00 | 48.33 | 67.50 |
| | attitude aft opinion poll | 58.12 | 65.61 | 48.20** | 42.11* | 71.11 | 46.67 | 67.50 |

# Complete model for the explanation of attitudes towards a fuel tax increase




| | | | |
|---|---|---|---|
| n | 227 | HFIVE | 216 |
| $\chi^2$ | 183.397 | RMSEA | 0.034 |
| df | 146 | PCLOSE | 0.971 |
| $\chi^2$/df | 1.256 | AIC def | 311.397 |
| P-value | 0.020 | AIC sat | 420.000 |
| GFI | 0.924 | AIC ind | 1,485.259 |

# Model for the comparison of different stakeholders regarding the determining factors of the attitudes towards a fuel tax increase




| Number | Citizens | Policy makers | Lobby groups |
|---|---|---|---|

| Factor loadings | | | |
|---|---|---|---|
| 1 | .42 | .54 | .71 |

| Covariances | | | |
|---|---|---|---|
| 2 | .42 | .48 | .22 |
| 3 | .00 | .40 | .34 |
| 4 | .67 | .52 | -.04 |
| 5 | .09 | .11 | .41 |

| Number | Citizens | Policy makers | Lobby groups |
|---|---|---|---|

| Regression weights | | | |
|---|---|---|---|
| 6 | .22 | .21 | -.16 |
| 7 | .38 | .07 | .07 |
| 8 | -.28 | -.30 | -.05 |
| 9 | -.26 | -.22 | -.08 |
| 10 | -.38 | .11 | .11 |
| 11 | -.07 | .35 | .29 |
| 12 | -.52 | -.20 | -.18 |
| 13 | .20 | .23 | .48 |
| 14 | .28 | .26 | -.09 |

| Squared multiple correlation | | | |
|---|---|---|---|
| 15 | .52 | .36 | .36 |

# Quasi experimental study 1

# Theory-Driven Subgroup-Specific Evaluation of an Intervention to Reduce Private Car Use[1]

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http://eab.sagepub.com/content/38/6/820.abstract

# Study Design and Research a quasi experimental study

- In the context of a 2-wave panel study, we used Ajzen's (1991) theory of planned behavior (TPB) as the theoretical framework for deriving and systematically testing hypotheses as to how an intervention (a "free" ticket for public transportation) influences the travel mode choice of students.
- The empirical results show that this intervention caused a drastic decrease in students' car use. The effect of the intervention on behavior is mediated by the causal chain postulated by the TPB.
- In the second step, we analyzed whether there were subgroup-specific reactions to the intervention. Surprisingly, the subgroup analysis shows that students with more negative attitudes toward policy measures restricting car use reacted more strongly to the intervention than did students with a more positive attitude.

# The Introduced Intervention

- The intervention “semester ticket” consists of an innovative concept for financing the collective good “public transportation.” It is based on the solidarity principle that all students must pay a contribution so that the individual burden is small.
- In exchange, the possession of a valid student identification card entitles all students to use public transportation “free of charge.” In Giessen, the semester ticket entitles the students to use all means of public transportation (buses and trains) within a radius of approximately 50 km and it costs students an additional 38 DM (approximately $22) to their normal university fees for one semester.
- This represents a drastic price reduction because the normal bus user must pay the same amount of money for the ordinary monthly ticket valid for the community buses in Giessen alone. Furthermore, the semester ticket facilitates the use of public transportation because it is no longer necessary to purchase a bus ticket.

# The Introduced Intervention

- Taken together, we hoped that the drastic price reduction and the simplification of public transportation use would create such a drastic situational change that habitual nonusers of public transportation would be motivated to reevaluate their behavioral choice.
- The semester ticket was introduced in May 1994. Prior to that, the student representatives had organized a vote in which the students themselves decided whether or not the semester ticket should be introduced. Among the participating students, 65% voted in favor of the semester ticket plan.

# Action Intervention Hypotheses

- **Intervention Hypothesis 1.** The introduction of the semester ticket will increase the subjective probability with which students associate the behavioral belief “cheap” with the use of public transportation for university routes. We assume that the drastic price reduction caused by the semester ticket will motivate former non-bus-users to test public transportation.
- Through this test they acquire information about the bus system (e.g., timetable, bus routes, bus stops), which facilitates the use of public transportation. Thus, the second intervention hypothesis postulates the following:
- **Intervention Hypothesis 2.** The introduction of the semester ticket will increase the subjective probability with which students think that they possess knowledge about timetables or existing bus connections (control beliefs), which are necessary prerequisites for the use of public transportation for university routes.

# Action Intervention Hypotheses

- **Intervention Hypothesis 3.** Because of the intensive public discussion and the subsequent vote about the introduction of the semester ticket, the perceived social expectations of significant others to use public transportation for university routes will increase following the introduction of the semester ticket.
- **Intervention Hypothesis 4.** The changes in the probabilities of these behavioral, normative, and control beliefs caused by the introduction of the semester ticket in their turn change the attitude, subjective norm, and PBC toward using public transportation for university routes in the same direction. Changes in attitude, subjective norm, and PBC should cause an increase in the actual use of public transportation for university routes via intention.

# Participants

- The study was conducted as a longitudinal panel study. The data collection of the first panel wave took place during the second week of February 1994, before the introduction of the semester-ticket intervention.
- Over a period of 8 working days, a questionnaire was distributed to 3,491 randomly selected students. Of these 3,491 questionnaires, 1,874 (53.7%) were completed and returned. Participants in the first panel wave were 41.I% male and ranged in age from 20 to 37 years, with a mean age of 24.4 years.
- As 19,902 students (without the first semesters) were enrolled in the summer semester 1994, this corresponds to 9.4% of all registered university students. The second panel wave was conducted in the first week of February 1995, 10 months after the introduction of the semester ticket.
- Because of residential mobility and a change in the student registration system, only 1,316 students received the questionnaire a second time. The response rate in the second wave was 78.8%, resulting in a sample of 1,036 students.

Table 1

*Stability and Change of Travel-Mode Decisions Between 1994 and 1995*

| Travel mode 1995 | Travel mode 1994 | | | | 1995 |
|---|---|---|---|---|---|
| | CAR 1994 | BIKE 1994 | BUS 1994 | PEDE 1994 | |
| CAR 1995 | 167 | 23 | 8 | 6 | 204 (30.0%) |
| BIKE 1995 | 24 | 168 | 12 | 14 | 218 (32.1%) |
| BUS 1995 | 88 | 31 | 77 | 13 | 209 (30.8%) |
| PEDE 1995 | 17 | 14 | 7 | 10 | 48 (7.1%) |
| 1994 | 296 (43.6%) | 236 (34.8%) | 104 (15.3%) | 43 (6.3%) | 679 (100%) |

*Note.* $N = 679$. BUS = public transportation, PEDE = pedestrians.

Table 2

*Means and Standard Deviations of TPB Variables for Bus Use Before (1994) and After Introduction of the Semester Ticket (1995)*

| | 1994 before | | 1995 after | | *p*-value of no difference* |
|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | |
| Evaluation of behavioral beliefs | | | | | |
| Fast | 1.42 | 0.83 | 1.46 | 0.76 | n.s.** |
| Comfortable | 0.50 | 1.06 | 0.59 | 1.11 | .05 |
| Without stress | 0.95 | 1.00 | 1.03 | 0.96 | n.s. |
| Cheap | 1.42 | 0.86 | 1.47 | 0.84 | n.s. |
| Ecological | 1.26 | 1.14 | 1.22 | 1.08 | n.s. |
| Subjective probability of behavioral beliefs | | | | | |
| Fast | -1.19 | 1.01 | -1.07 | 1.05 | <.05 |
| Comfortable | -0.10 | 1.28 | -0.02 | 1.29 | n.s. |
| Without stress | -0.26 | 1.22 | -0.33 | 1.26 | n.s. |
| Cheap | -0.84 | 1.23 | 0.78 | 1.47 | <.01 |
| Ecological | 0.23 | 1.18 | 0.40 | 1.00 | <.01 |
| Evaluation of control beliefs | | | | | |
| Good bus connection | 0.05 | 1.54 | -0.66 | 1.42 | <.01 |
| Departure knowledge | -0.36 | 1.61 | 0.14 | 1.65 | <.01 |
| Subjective probability of control beliefs | | | | | |
| Good bus connection | 0.05 | 1.54 | -0.66 | 1.42 | <.01 |
| Departure knowledge | -0.36 | 1.61 | 0.14 | 1.65 | <.01 |
| Indicators of latent constructs: attitude, norm, perceived behavioral control (PBC), and intention | | | | | |
| Attitude 1 | -0.65 | 1.10 | -0.34 | 1.21 | <.01 |
| Attitude 2 | -0.73 | 1.06 | -0.51 | 1.12 | <.01 |
| Norm 1 | -0.67 | 1.18 | -0.39 | 1.27 | <.01 |
| Norm 2 | -0.87 | 1.13 | -0.76 | 1.20 | <.05 |
| PBC 1 | -0.49 | 1.49 | -0.16 | 1.61 | <.01 |
| PBC 2 | -0.39 | 1.57 | 0.10 | 1.63 | <.01 |
| Intention 1 | -1.39 | 1.14 | -0.97 | 1.46 | <.01 |
| Intention 2 | -1.38 | 1.15 | -0.89 | 1.49 | <.01 |

*Note*. The means are based on those subjects ($N = 622$) who participated in both waves and have no missing values in the variables. All response scales range from -2 to +2. The labels "Attitude 1," "Attitude 2," etc. refer to the two items measuring each TPB-construct (Appendix A).

*$p$ refers to the result of a $t$-test comparing the mean at wave 1 with that at wave 2.

**n.s. = not significant; $p > .05$.

# Quasi experimental study 2

# Generalization of the „Semesterticket“ effects to all German universities

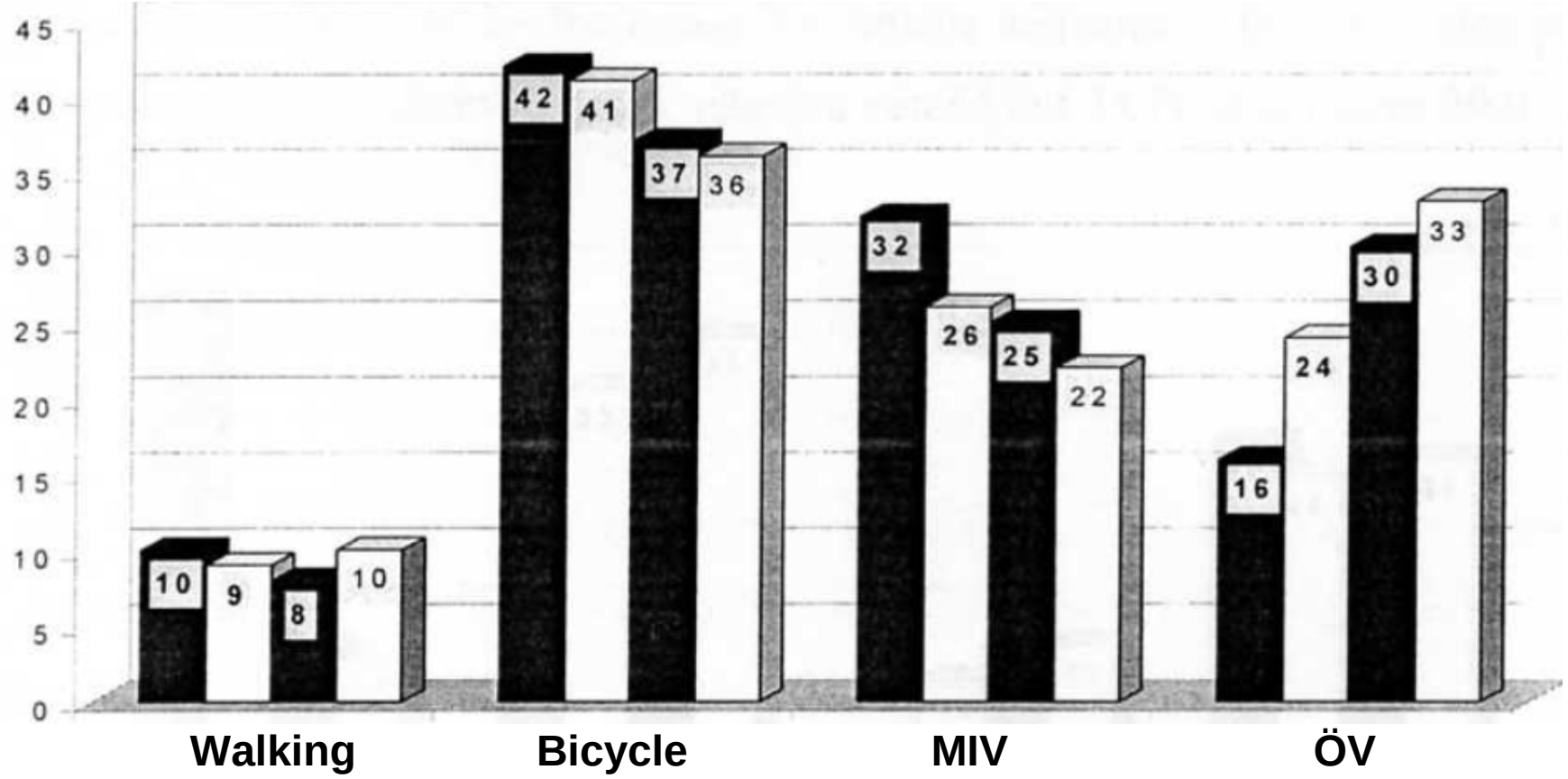
# Semesterticket: Diffussion of an innovation

- The first Semesterticket was introduced at the Darmstadt University of Applied science in 1991 .
- Then followed the universities of Kaiserslautern and Gießen.
- Target group were all 1,9 Million german students.
- 2010 approx. 1.6 miliion students have a semester ticket.

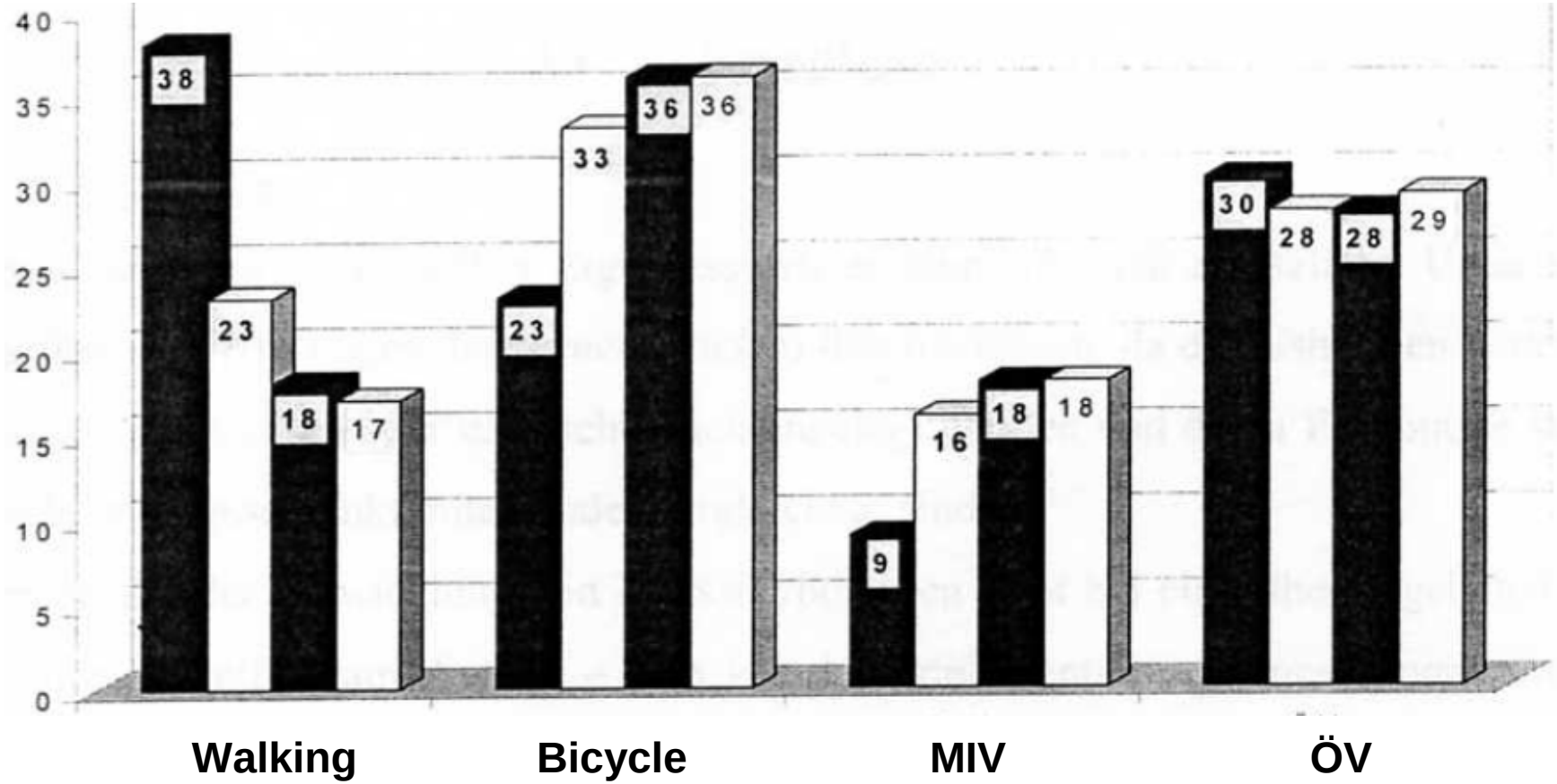
# German Student Survey (Sozialerhebung)

| Nr. | Year | Universities | Net sample | Respons Rate |
|---|---|---|---|---|
| 13 | 1991 | All Universities | 26.525 | 48% |
| 14 | 1994 | | 27.535 | 50% |
| 15 | 1997 | | 20.533 | 37% |
| 16 | 2000 | | 12.573 | 27% |

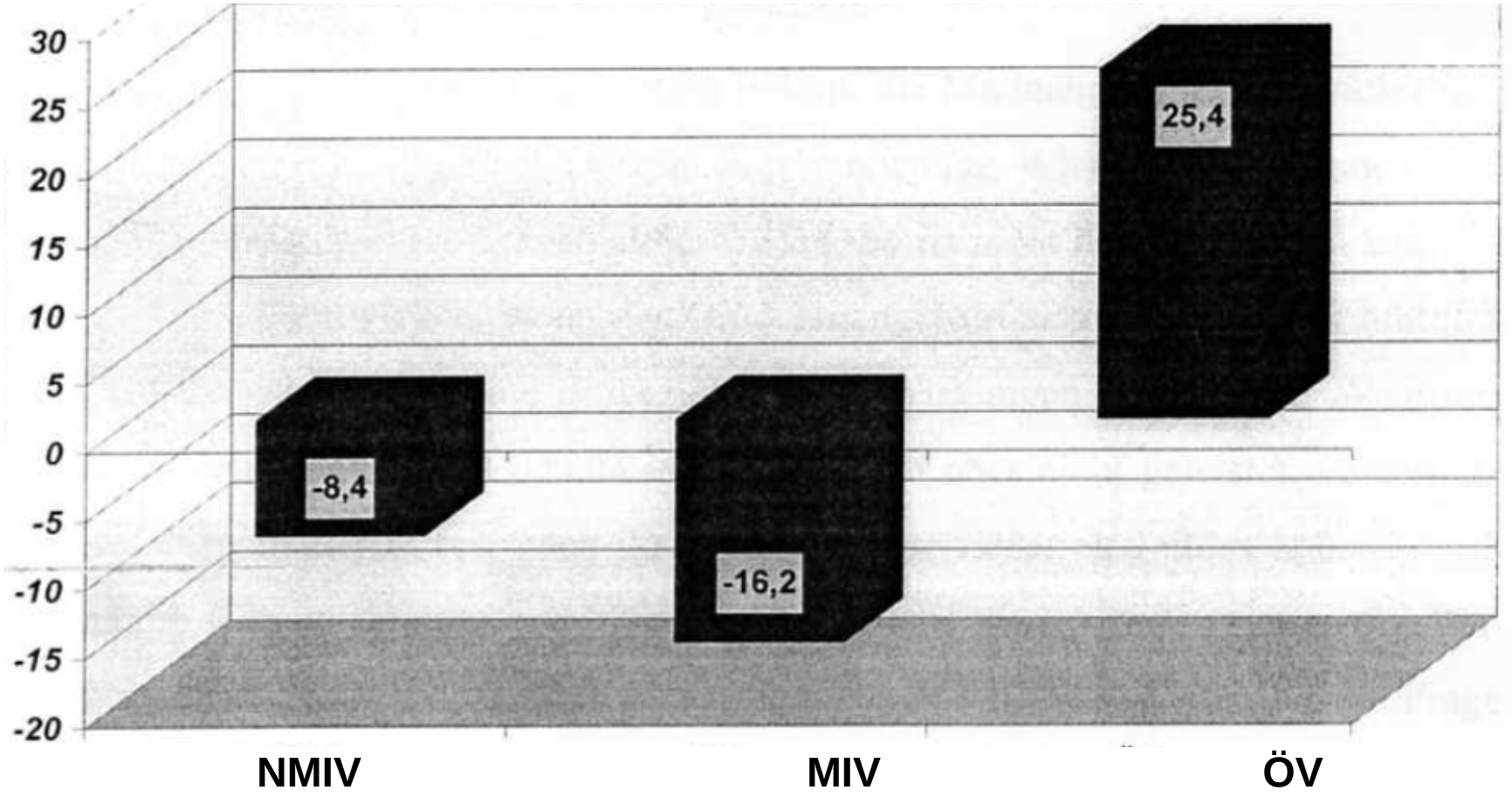
# Development of Travel Mode Choice in West-German Universitys 1991 - 2000



# Development of Travel Mode Choice in East-German Universitys 1991 - 2000



# Change of Model Split between 1991 and 2000 for Universities which introduced the component Semesterticket



# Experimental study in Stuttgart

**Is a Residential Relocation a Good Opportunity to Change People's Travel Behavior? Results From a Theory-Driven Intervention Study**

Sebastian Bamberg

*Environment and Behavior* 2006 38: 820
DOI: 10.1177/0013916505285091

# Abstract


- This article presents an experimental, theory-driven evaluation of the effectiveness of an intervention that combines a free public transportation ticket and personal schedule information on the subsequent use of public transportation in an urban area.
- The time point when participants received this intervention is unusual. It was delivered to them shortly after a residential relocation. It is assumed that such a situation increases people's responsiveness to the intervention. At their new living place, the intervention group shows a strong increase in public transportation use.
- The intervention effect on the individual choice process is modeled via Ajzen's theory of planned behavior. Besides a main effect on intention, results indicate interactions between the intervention and the change intention existing prior to the move and higher objective public transport service quality after the move.

# In the present study

- The systematic review of intervention outcomes is an important first step toward a more evidence-based judgment of what might work in motivating people to reduce their car use. But summarizing and comparing average intervention effects per se provides little insight into the conditions and mechanisms mediating these effects. Thus, the goal of the present study is not only to evaluate the effect of an intervention on people's car use but also to model and test the causally mediating mechanisms of this effect.
- In the present study, an intervention that combines a small material incentive (a 1-day free ticket for PT) with personally tailored PT services and schedule information is evaluated. An unusual point is the situation in which this intervention was delivered. It was given to a group of people about 6 weeks after their relocation to a new residence.

# In the present study

- Such a move marks a deep biographical cut that forces people to deliberately reorganize their daily lives in general and their daily travel behavior. It is assumed that the first weeks after the move may create a sensitive phase when people are motivated to pay more attention to information about other mobility alternatives to the car and are more willing to actually test these alternatives.
- As a consequence, the intervention may be more effective in such a sensitive phase than in stable contexts.

# Study design and participants

- The study was a randomized controlled trial designed to assess the efficacy of the intervention and involved the three stages of baseline measurement before the move, intervention implementation after the move, and measurement after the intervention. Participants who planned to move to Stuttgart within a 6-month period were recruited by post, e-mail, and telephone; addresses and numbers were obtained from rent advertisements appearing in Stuttgart newspapers.
- A lottery with attractive monetary prizes was used as an incentive to participate. To reduce self-selection and strategic reasoning, participants were not informed that they were participating in an experimental intervention study. Instead, the study was presented as a university research project aimed at analyzing the impact of a residential relocation on daily mobility patterns.

# Study design and participants

- From the about 800 persons contacted in this way at their old residence prior to their move, 535 signaled interest in participating in the study and received the first questionnaire. Of these 535 persons, 241 actually completed the first questionnaire and sent it back to us.
- The mean age of these 241 participants was 28.6 years (ranging from 17-58 years), 53% were male, 41% reported that they had a university degree, 98% had a driving license, and 66% reported that they could always use a car.

# Study design and participants

- These 241 participants were randomly assigned to a control (*n = 123) and* experimental group (*n = 118). Six months after completing the first questionnaire,* 191 (99 in the control and 92 in the experimental group) of the 241 participants had actually moved to Stuttgart and were recontacted at their new residence.
- Those 92 participants assigned to the experimental group received the intervention via mail about 6 weeks after the move. As an additional measure to reduce the reactivity of our design, the intervention was sent to the participants by the local transport company, which did not make any reference to our research project. By this procedure, we tried to prevent people from associating the questionnaires with the received intervention. About 12 weeks after their move, all 191 participants received a second questionnaire via mail.

# Study design and participants

- Of these 191 participants, 169 completed the second questionnaire (90 in the control and 79 in the experimental group). To check whether a systematic self-selection process occurs between Wave 1 (*n = 241) and Wave 2 (n = 169), a logistic regression analysis was* conducted with participation in Wave 2 as the dependent variable. Entering sociodemographic variables, the TPB variables, and travel behavior measured at the old residence as predictors provide no empirical evidence for a systematic self-selection process.

**TABLE 1**
**Means and Standard Deviations of Travel Behavior, the Theory of Planned Behavior Variables, and Habits Before and After the Move**

| | *Before Move* | | *After Move* | |
|---|---|---|---|---|
| | M | SD | M | SD |
| Public transport (PT) use | 18.20 | 0.39 | 35.80*** | 0.48 |
| Car use | 51.50 | 0.50 | 39.40** | 0.49 |
| Bicycle riding | 11.50 | 0.32 | 7.30 | 0.26 |
| Walking | 15.80 | 0.37 | 17.50 | 0.38 |
| PT attitude | 2.25 | 2.36 | 3.34*** | 2.60 |
| PT subjective norm | 2.48 | 2.62 | 3.56*** | 2.85 |
| PT perceived behavioral control (PBC) | 2.22 | 2.63 | 3.65*** | 2.96 |
| PT intention | 2.43 | 3.52 | 3.89*** | 3.86 |
| Car attitude | 5.11 | 3.11 | 4.60* | 2.90 |
| Car subjective norm | 4.65 | 3.33 | 4.02* | 3.17 |
| Car PBC | 5.28 | 3.40 | 4.58* | 3.39 |
| Car intention | 4.74 | 4.11 | 4.02* | 3.97 |
| Car availability | 7.34 | 4.13 | 6.73* | 4.36 |
| PT habit | 0.64 | 1.13 | 0.90* | 1.49 |
| Car habit | 2.70 | 2.30 | 2.07*** | 2.06 |

NOTE: Significance of before or after move differences were tested by dependent *t* tests.
*$p < .05$. **$p < .01$. ***$p < .001$.

**TABLE 2**
**Means and Standard Deviations of Behavior, the Theory of Planned Behavior Constructs, and Contextual Factors Before and After the Move for Control Group and Experimental Group Separately**

| | *Before Move* | | | | *After Move* | | | | *Before-After Comparison* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Control Group*[a] | | *Experimental Group*[b] | | *Control Group*[a] | | *Experimental Group*[b] | | *Control Group*[a] | *Experimental Group*[b] |
| *Variable* | M | SD | M | SD | M | SD | M | SD | p | p |
| Public transport (PT) use | 0.18 | 0.39 | 0.18 | 0.39 | 0.25 | 0.44 | 0.47** | 0.50 | | *** |
| Car use | 0.55 | 0.50 | 0.50 | 0.50 | 0.45 | 0.50 | 0.33 | 0.47 | | * |
| PT intention | 2.56 | 3.46 | 2.28 | 3.62 | 3.17 | 3.45 | 4.70** | 4.14 | | *** |
| PT attitude | 2.35 | 2.30 | 2.15 | 2.43 | 3.01 | 2.33 | 3.71 | 2.84 | * | *** |
| PT subjective norm | 2.74 | 2.53 | 2.18 | 2.70 | 3.42 | 2.69 | 3.71 | 3.02 | * | *** |
| PT perceived behavioral control (PBC) | 2.47 | 2.69 | 1.95 | 2.56 | 3.22 | 2.66 | 4.13* | 3.20 | * | *** |
| Car intention | 4.76 | 4.05 | 4.71 | 4.20 | 4.45 | 4.00 | 3.54 | 3.91 | | * |
| Car attitude | 4.84 | 3.10 | 5.40 | 3.12 | 4.80 | 2.69 | 4.36 | 2.90 | | * |
| Car subjective norm | 4.30 | 3.15 | 5.05 | 3.51 | 4.01 | 3.08 | 4.04 | 3.28 | | * |
| Car PBC | 5.15 | 3.25 | 5.42 | 3.57 | 4.71 | 3.41 | 4.44 | 3.37 | | * |
| PT habit strength | 0.57 | 1.18 | 0.72 | 1.08 | 0.68 | 1.24 | 1.15* | 1.70 | | * |
| Car habit strength | 2.79 | 2.31 | 2.69 | 2.29 | 2.10 | 2.05 | 2.03 | 2.09 | ** | * |
| Car availability | 7.25 | 4.12 | 7.44 | 4.17 | 6.94 | 4.31 | 6.49 | 4.44 | | * |
| Change motivation | 0.85 | 1.26 | 0.89 | 1.26 | — | — | — | — | | |
| Old residence size | 243.60 | 296.60 | 206.10 | 456.80 | — | — | — | — | | |
| PT quality new residence | — | — | — | — | 31.30 | 47.80 | 44.50 | 45.80 | | |

a. $n = 90$.
b. $n = 79$.
*$p < .05$, **$p < .01$, ***$p < .0001$.

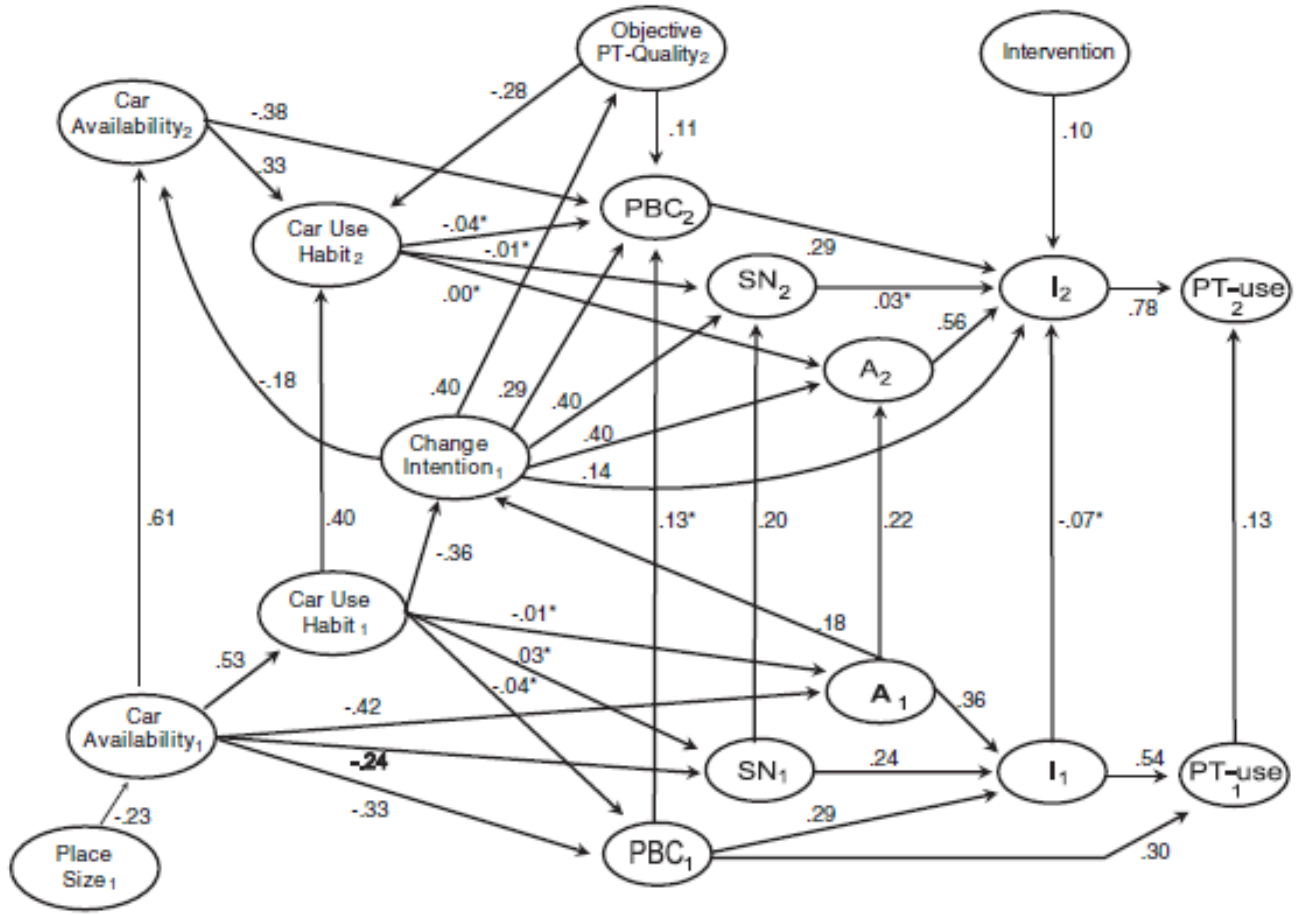



**Figure 1: Graphical Presentation of the Estimated Structural Model**

NOTE: A = attitude toward Public transport (PT) use; SN = subjective norm toward PT use; PBC = perceived behavioral control over PT use; I = intention to use PT. The subscripts 1 and 2 refer to Wave 1 (before) and Wave 2 (after the move). Completely standardized coefficients are reported.
*Not significant at $p < .05$.

# Limitations of the study

- This reasoning directly leads to one weakness of the present study. It allows only an indirect analysis of the impact of a residential relocation. Comparing the intervention effects in a sample of people moving to Stuttgart with a sample of people already living in Stuttgart would allow a more direct test of the sensitive phase hypothesis.
- A lack of later follow-up measurements of participants'travel behaviors is another weakness. I am a little skeptical about how sustainable the drastic behavioral change was and expect that a later measurement would have shown a reincrease in car use. But as is often the case in evaluation research, time and money constraints have impaired the use of a more adequate research design.

# Meta analytic structure equation modeling (MASEM) for theory

# Meta-Analysis of the Theory of Planned Behavior

based on: S. Timptner: A Metaanalytic Structural Equation Approach for the TOPB: Testing for Moderator Effects.

# Steps of Meta-Analysis

- *Integration of single findings*
  - Single findings has to be transformed in standardized effect sizes
  - Computing mean effect sizes

- *Examining the variance*
  - Testing for homogeneity
  - Empirical examination of moderator effects

# Test of homogeneity

- The homogeneity test Q examines the assumption that all effect sizes are estimating the same population value.
- *Homogenous distribution*: Effect sizes differ from population mean only by sampling error.
- *Heterogeneous distribution:* Effect sizes does not estimate a common population mean.

(Lipsey & Wilson, 2001)

# Moderator analysis

- Exploring sources of heterogeneity
- Examining effect sizes concerning different study characteristics:
  - Methodological moderators
  - Conceptual moderators
- Statistical control
- Subgroup analysis

# Hypothesis

- *H1:* The strength of the relationships between the TpB-constructs depends on the kind of behavior.
- *H2:* The correction for attenuation leads to higher correlations between the TpB-constructs.
- *H3:* The correlations between intention and behavior are higher when the behavior is measured by self-report, and lower when the behavior is measured by observation.

# Hypothesis

- *H4:* The correlations between intention and behavior are higher when the behavior is measured at the same time as the other TpB- constructs, and lower when the behavior is measured at a later time.
- *H5:* The correlations between the TpB-constructs are higher when the principle of compatibility is adhered to and lower if it's not.

# Selection of relevant studies

- Literature research result: 651 references dealing with the TpB.
- 369 studies could be obtained online and for free over the OPAC of the University of Gießen.
- From these, correlations for 350 behaviors could be found.
- Because coding and a second data check is very time consuming, this meta-analysis is based on 132 studies, published from 1986 – 2007.

# Meta-analytic structural equation modeling (MASEM)

- Testing the causal relationships in the comprehensive TpB-Model.
- Does the theoretical model fit to the data?
- Calculating a MASEM-Model for each subgroup by using AMOS, based on the mean effect sizes.
- Comparing the model fits, standardized path coefficients and explained variances for detecting moderator effects.

# Mean effect sizes: All studies included

| | Observed mean effect sizes | Mean effect sizes corrected for attenuation | N effect sizes | N sample sizes |
|---|---|---|---|---|
| Attitude - S.Norm | 0,39 | 0,56 | 102 | 23140 |
| Attitude - Control | 0,33 | 0,51 | 109 | 23785 |
| Attitude - Intention | 0,55 | 0,70 | 121 | 25375 |
| Attitude - Behavior | 0,37 | 0,44 | 83 | 16764 |
| S.Norm - Control | 0,23 | 0,32 | 103 | 23007 |
| S.Norm - Intention | 0,42 | 0,57 | 112 | 23852 |
| S.Norm - Behavior | 0,29 | 0,36 | 77 | 15627 |
| Control - Intention | 0,45 | 0,65 | 119 | 24650 |
| Control - Behavior | 0,29 | 0,39 | 84 | 16589 |
| Intention - Behavior | 0,55 | 0,64 | 83 | 16136 |

All effect sizes significantly different from zero (p = 0,00)

All Q-statistics significant (p = 0,00)

# Mean effect sizes: Environmental behavior

| | Observed mean effect sizes | Mean effect sizes corrected for attenuation | N effect sizes | N sample sizes |
|---|---|---|---|---|
| Attitude - S.Norm | 0,23 | 0,42 | 6 | 1212 |
| Attitude - Control | 0,35 | 0,90 | 6 | 1212 |
| Attitude - Intention | 0,52 | 0,95 | 5 | 1148 |
| Attitude - Behavior | 0,49 | 0,80 | 3 | 750 |
| S.Norm - Control | 0,16 | 0,30 | 6 | 1212 |
| S.Norm - Intention | 0,27 | 0,43 | 5 | 1148 |
| S.Norm - Behavior | 0,23 | 0,34 | 4 | 814 |
| Control - Intention | 0,45 | 0,90 | 5 | 1148 |
| Control - Behavior | 0,41 | 0,72 | 4 | 814 |
| Intention - Behavior | 0,57 | 0,75 | 3 | 750 |

All effect sizes significantly different from zero (p = 0,00)

All Q-statistics significant (p < 0,05)

# Mean effect sizes: Traffic behavior

| | Observed mean effect sizes | Mean effect sizes corrected for attenuation | N effect sizes | N sample sizes |
|---|---|---|---|---|
| Attitude - S.Norm | 0,67 | 0,93 | 8 | 2413 |
| Attitude - Control | 0,59 | 0,82 | 8 | 2413 |
| Attitude - Intention | 0,70 | 0,90 | 8 | 2413 |
| Attitude - Behavior | 0,54 | 0,66 | 8 | 2413 |
| S.Norm - Control | 0,53 | 0,68 | 8 | 2413 |
| S.Norm - Intention | 0,69 | 0,91 | 8 | 2413 |
| S.Norm - Behavior | 0,54 | 0,66 | 8 | 2413 |
| Control - Intention | 0,67 | 0,88 | 8 | 2413 |
| Control - Behavior | 0,56 | 0,76 | 8 | 2413 |
| Intention - Behavior | 0,78 | 0,93 | 8 | 2413 |

All effect sizes significantly different from zero (p = 0,00)

All Q-statistics significant (p < 0,05)

# Mean effect sizes: Self-reported behavior vs. observed behavior

| | Mean effect sizes | N effect sizes | N sample sizes |
|---|---|---|---|
| Intention - Self-reported behavior | 0,58 | 69 | 14168 |
| Intention - Observed behavior | 0,36* | 14 | 1968 |

Alle Effektstärken sind mit p = 0,00 signifikant von null verschieden

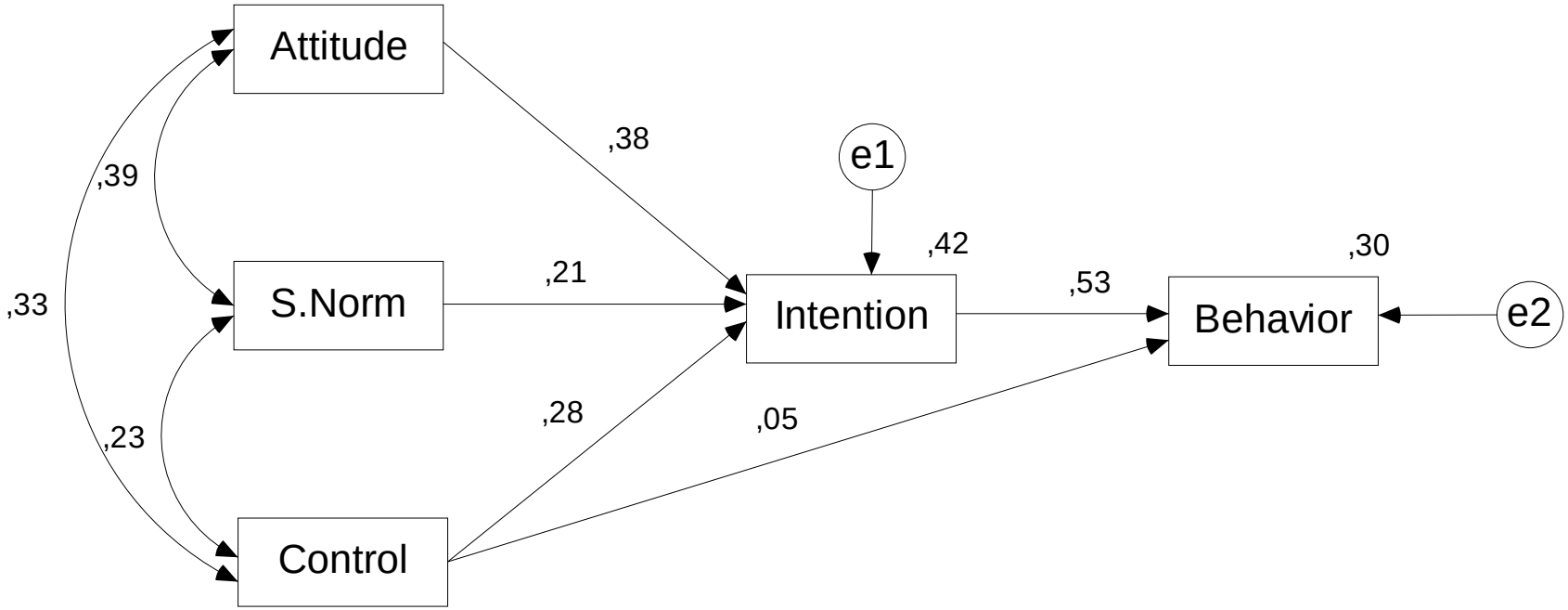
* Homogenitätstest mit p = 0,24 signifikant

# Mean effect sizes: Behavior measurement at a later time vs. behavior measurement at the same time

| | Mean effect sizes | N effect sizes | N sample sizes |
|---|---|---|---|
| Intention - Behavior measurement at a later time | 0,52 | 52 | 8345 |
| Intention - Behavior measurement at the same time | 0,59 | 31 | 7791 |

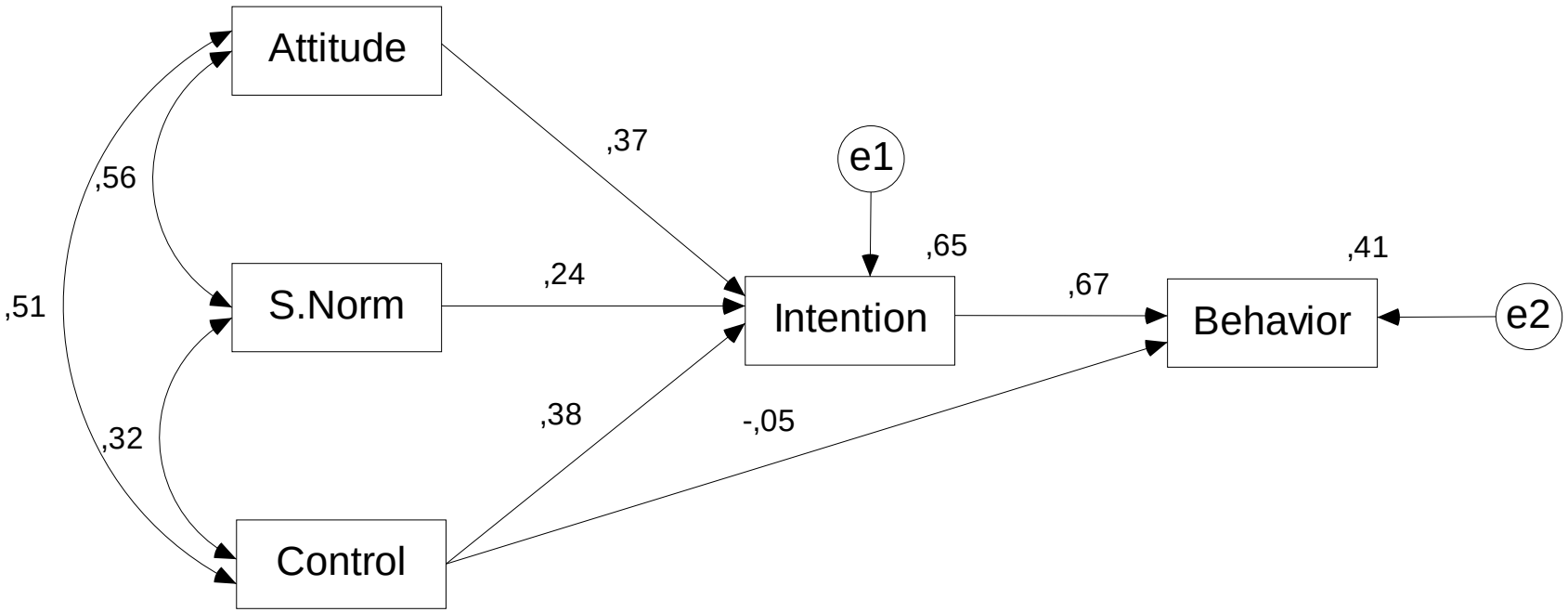
Alle Effektstärken sind mit p = 0,00 signifikant von null verschieden
Alle Homogenitätstest mit p = 0,00 signifikant

# MASEM




Model 1 - MASEM all studies included, without correction for attenuation
(N = 20140)
CFI = ,990

# MASEM




Model 2 - MASEM all studies included, with correction for attenuation
(N = 20140)
CFI = 1,000

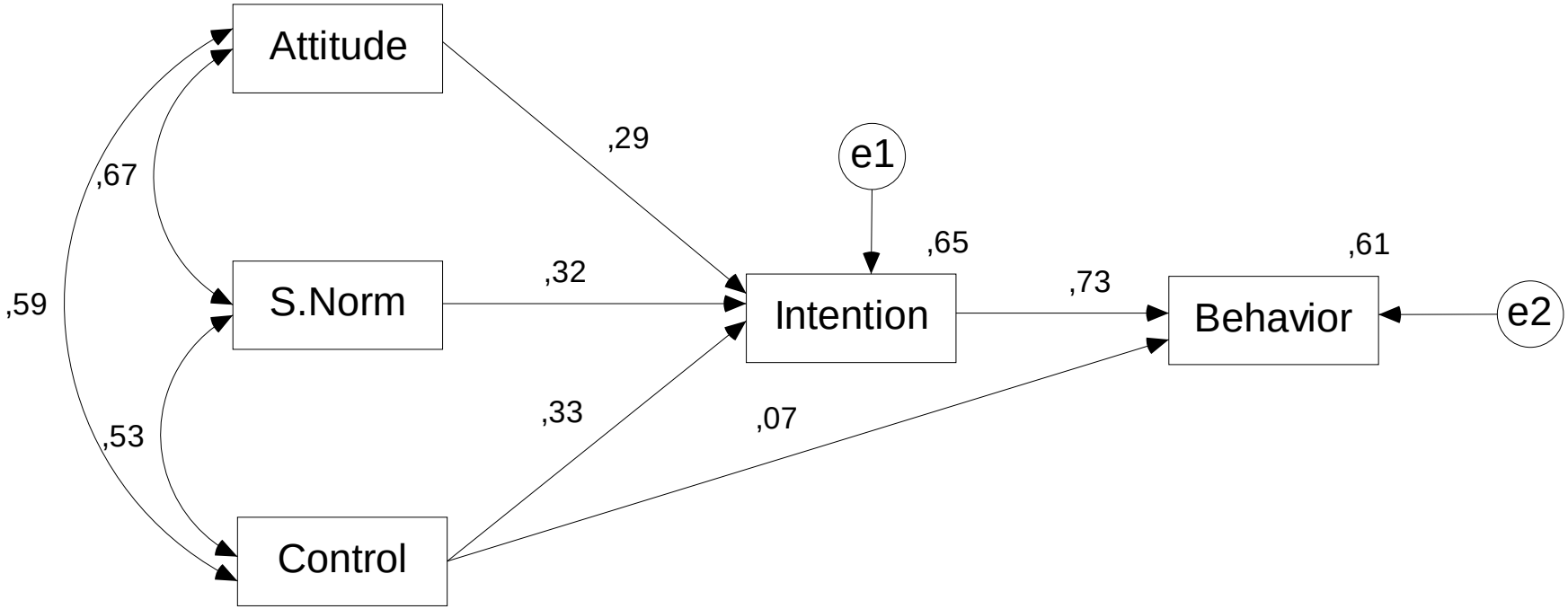
# Mean effect sizes: Traffic behavior

| | Observed mean effect sizes | Mean effect sizes corrected for attenuation | N effect sizes | N sample sizes |
|---|---|---|---|---|
| Attitude - S.Norm | 0,67 | 0,93 | 8 | 2413 |
| Attitude - Control | 0,59 | 0,82 | 8 | 2413 |
| Attitude - Intention | 0,70 | 0,90 | 8 | 2413 |
| Attitude - Behavior | 0,54 | 0,66 | 8 | 2413 |
| S.Norm - Control | 0,53 | 0,68 | 8 | 2413 |
| S.Norm - Intention | 0,69 | 0,91 | 8 | 2413 |
| S.Norm - Behavior | 0,54 | 0,66 | 8 | 2413 |
| Control - Intention | 0,67 | 0,88 | 8 | 2413 |
| Control - Behavior | 0,56 | 0,76 | 8 | 2413 |
| Intention - Behavior | 0,78 | 0,93 | 8 | 2413 |

All effect sizes significantly different from zero (p = 0,00)

All Q-statistics significant (p < 0,05)

# MASEM




Model 11 - MASEM Traffic Behavior

(N = 2413)

CFI = 1,000

# Meta analytic structure equation modeling (MASEM) for theory and intervention

# Behaviour Theory and Soft Transport Policy Measures

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**Margareta Friman**
Karlstad University, Sweden

**Tommy Gärling**
Karlstad University and University of Gothenburg, Göteborg, Sweden

# Abstract


- The aim is to propose a theoretical grounding of soft transport policy measures to promote voluntary reduction of car use. A general conceptual framework is first presented to clarify how hard and soft transport policy measures impact on car-use reduction.
- Two different behavioural theories that have been used to account for car use and car-use reduction are then integrated in a self-regulation theory that identifies four stages of the process of voluntarily changing car use: setting a car-use reduction goal, forming a plan for achieving the goal, initiating and executing the plan, and evaluating the outcome of the plan execution.
- A number of techniques are described that facilitate the different stages of the process of voluntary car-use reduction and which should be used in personalized travel planning programs.

# Evidence for the effectiveness of soft transport policy measures

- Several narrative reviews (Brög et al., 2009; Cairns et al., 2008; Richter et al., 2010a; Taylor, 2007) have concluded that soft transport policy measures are effective. Two meta-analyses (a technique that provides quantitative estimates of treatment effects, see e.g. Lipsey & Wilson, 2001) of previous research results have also been conducted. In one of these meta-analysis Möser and Bamberg (2008) synthesised the results of 141 studies evaluating the car-use reduction effects of workplace travel plans (44 studies), school travel plans (25 studies), and travel awareness campaigns/marketing of public transport (72 studies).
- Across all 141 studies a significant standardised mean effect size of 0.15 (Cohen's *h*) was found, corresponding to a 11% decrease of the proportion of trips conducted by car (from 61% to 54%). However, all studies used a quasi-experimental single treatment group before-after test design that fails to control for several factors that reduce the internal validity of causal inferences (Fujii et al., 2009; Stopher et al., 2009). Furthermore, external validity or generalizability of the results is threatened by the fact that most of the synthesised evaluation results were based on non-representative samples.

# Evidence for the effectiveness of soft transport policy measures

- In the second meta-analysis Fujii et al. (2009) used data from evaluation studies of 15 Japanese PTP programs (referred to as ”travel feedback programs”). The methodological quality of these studies is higher because they incorporated comparison or control groups in a before-after test design, which increases internal validity. A standardised mean effect size of 0.17 (Cohen’s *d*) was calculated. This corresponds to a decrease in the average number of weekly car trips from 6.9 to 5.7.
- However, the total number of studies was small and most of them were based on small non-representative samples. Furthermore, at least some of the studies seem to have used non-equivalent treatment and comparison groups, thus making it difficult to rule out alternative explanations for the reported before-after test differences.
- One recognized research priority is longitudinal panel studies that examine the time course of changes in travel.

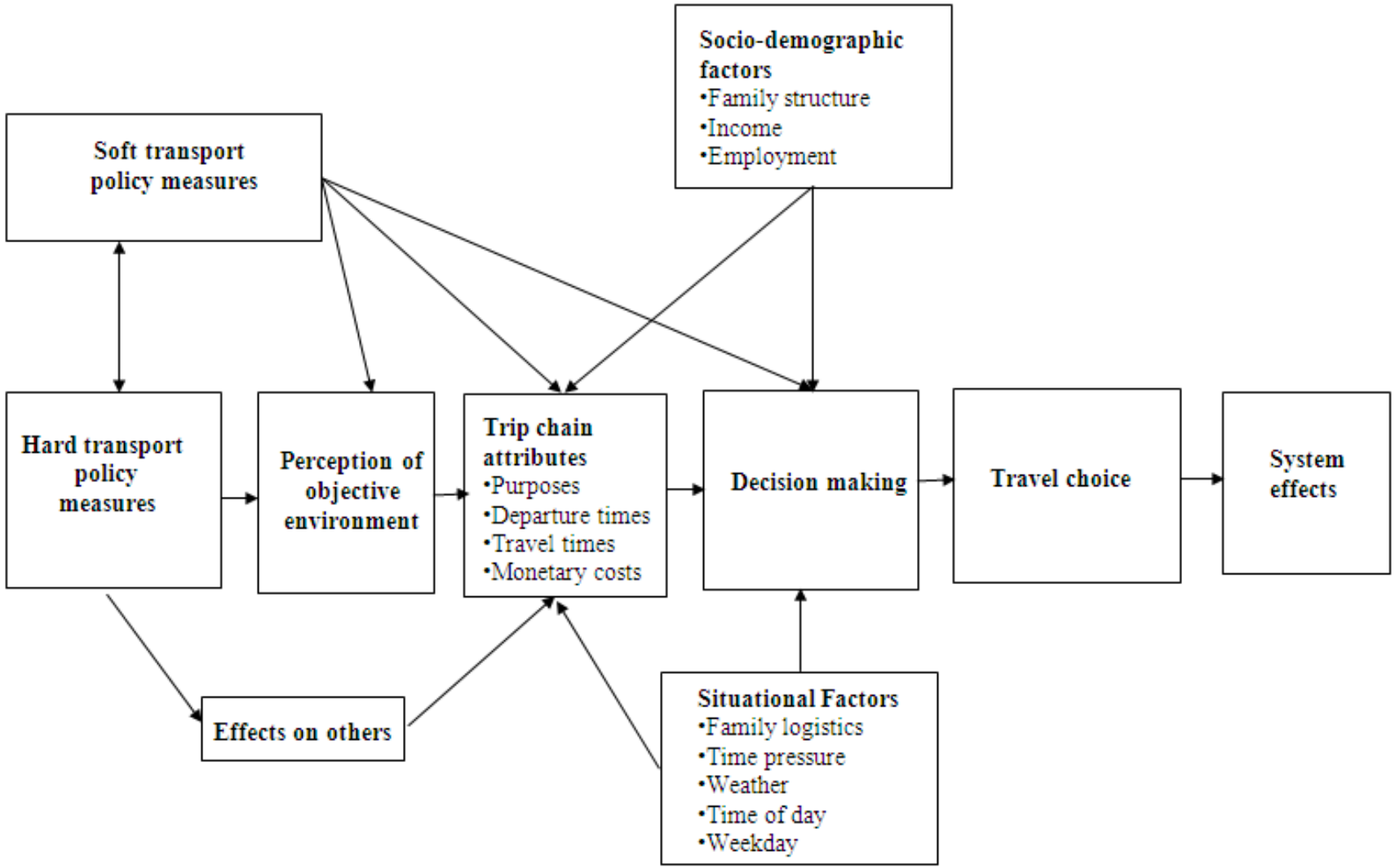
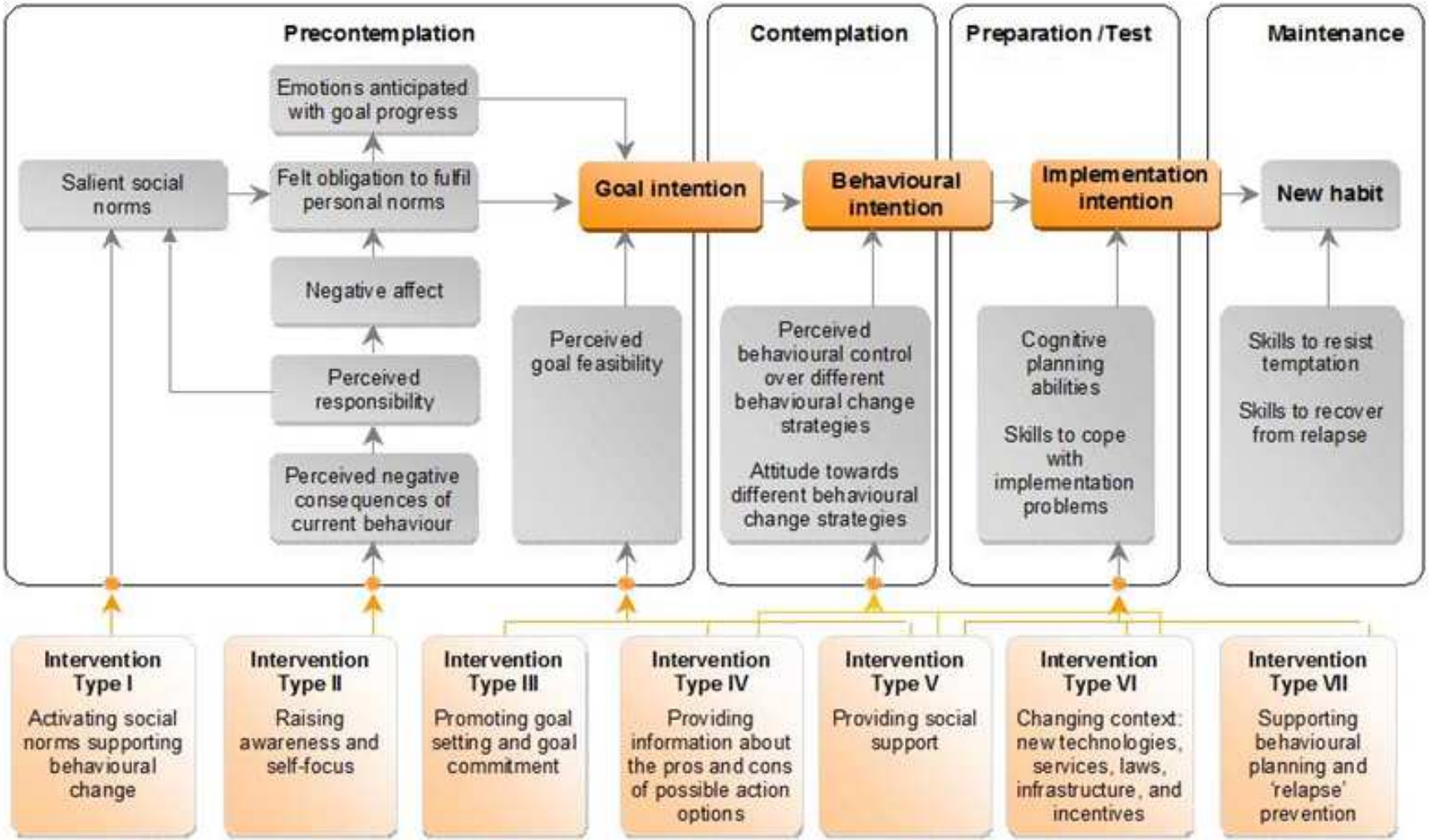



Fig. 1. A general conceptual framework


Precontemplation
Contemplation
Preparation /Test
Maintenance
Emotions anticipated with goal progress
Salient social norms
Felt obligation to fulfil personal norms
Goal intention
Behavioural intention
Implementation intention
New habit
Negative affect
Perceived responsibility
Perceived negative consequences of current behaviour
Perceived goal feasibility
Perceived behavioural control over different behavioural change strategies
Attitude towards different behavioural change strategies
Cognitive planning abilities
Skills to cope with implementation problems
Skills to resist temptation
Skills to recover from relapse
Intervention Type I
Activating social norms supporting behavioural change
Intervention Type II
Raising awareness and self-focus
Intervention Type III
Promoting goal setting and goal commitment
Intervention Type IV
Providing information about the pros and cons of possible action options
Intervention Type V
Providing social support
Intervention Type VI
Changing context: new technologies, services, laws, infrastructure, and incentives
Intervention Type VII
Supporting behavioural planning and 'relapse' prevention

# What is needed

1. Explicit theoretical approaches like the TOPB instead of Black Box evaluations.
2. longitudinal intervention studies with strong quasiexperimental or if possible experimental designs to test the most promising policy measures.
3. Generalized latent variable models like implemented in MPLUS software to take into account random measurement error, nonrandom measurment error,different scale levels, indirect and total effects, mediated and moderated effects, contextual effects and taking into account heterogeneity of Samples.
4. Metaanalyses for summarising the theoretical knowledge and interventuion results using structural equation modeling for developing adequate policy measures and integrating the knowledge.