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# Modelling Impacts of Beliefs and Attitudes on Mode Choices

## Lessons From a Survey of Luxembourg's Cross-border Commuters

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### Introduction

This presentation shows an attempt to measure and relate environmental beliefs/concerns and attitudes about the car and the train (as latent constructs) to the self-declared satisfaction in commuting and the perceived utility of transportation modes (latent) for commuting using a survey of Luxembourg's cross-border commuters. The main objective is to illustrate the use of structural equation models (SEM) as a data-mining tool to unravel the endogenous relationships among measurements, satisfaction and the perceived utility within the theory of planned behaviour (TPB; Ajzen 1991) conceptual framework. Shortcomings of the analytical procedure and suggestions to enhance the integration of beliefs and attitudes are discussed. It identifies ways to improve measurement of perceptual indicators and beliefs needed to identify latent sociopsychological factors and mediators that potentially condition mode choices for commuting on top of usual factors of socio-economic status, lifestyle, accessibility, parking availability/costs, public transit service levels, etc.

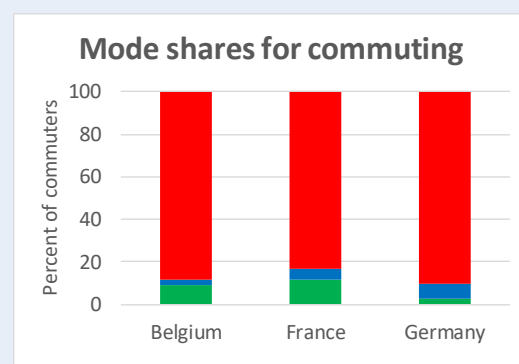
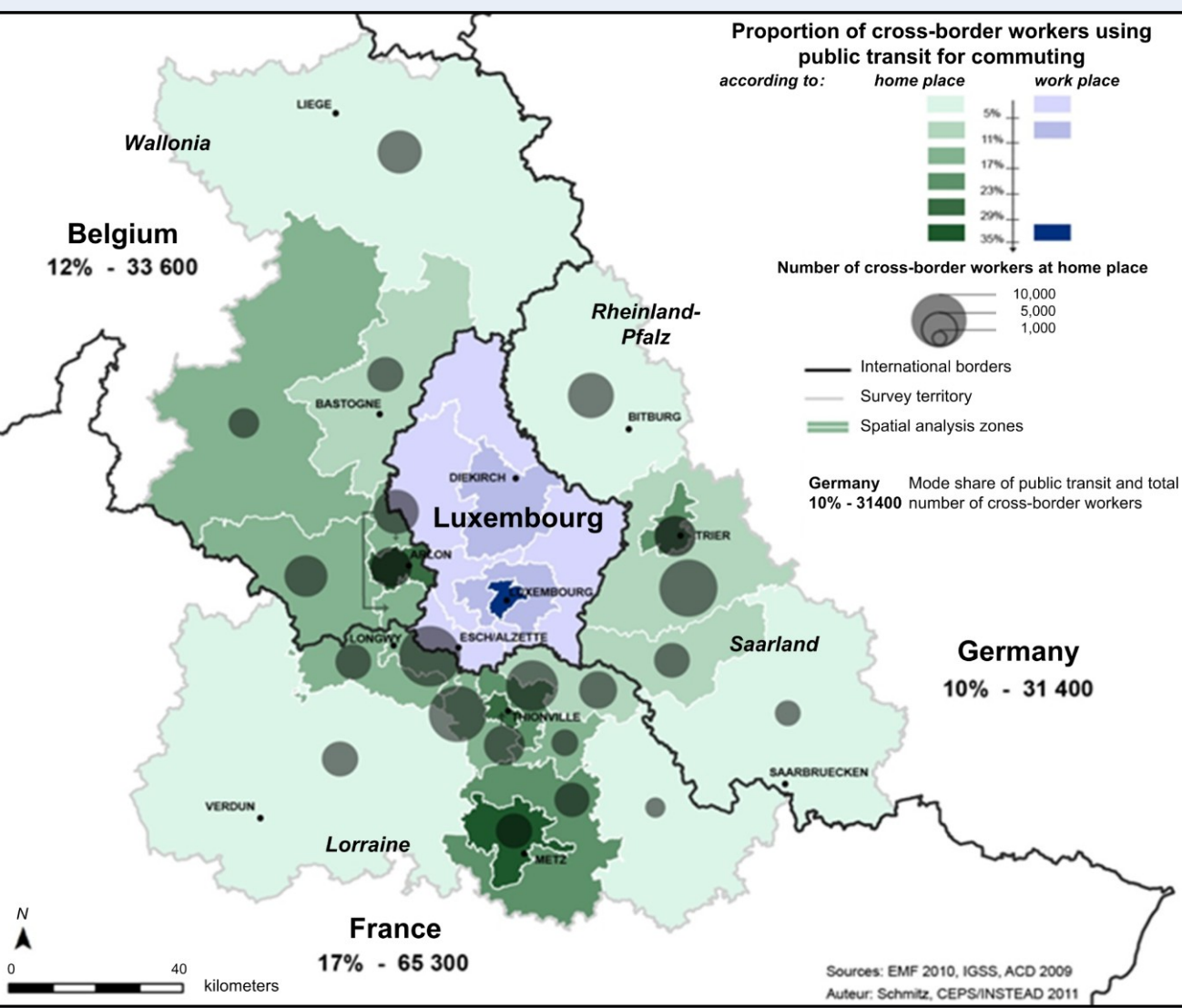
Ajzen, I. 1991. The theory of planned behaviour. *Organizational Behavior and Human Decision Processes*, 50, 179-211.

### The Survey (Mobility, Resources, Satisfaction, Attitudes)

LISER (Luxembourg Institute of Socio-Economic Research) conducted a self-administered 2-phase pencil-and-paper mobility survey among Luxembourg cross-border workers. The first phase was about the usual themes of a National Transport Survey. The second phase was concentrating on travel satisfaction, and the impact of beliefs, motivations and attitudes on mobility choices and environmental concerns. 40,000 workers were selected at random within a commuting area that assumes one return journey to work per day in France, Belgium and Germany. The sampling frame was controlled for socio-demographic factors and stratified in space (25 zones). The first phase (2010) attracted 7,235 respondents (response rate 18%). A second phase was undertaken in 2011 to enhance our understanding of the impact of beliefs, motivations and attitudes on mobility choices. It attracted 3,727 respondents among those of the first phase (52% retention rate).

The map below shows the mode shares of public transit (PT) according to home location outside Luxembourg and to work place inside Luxembourg. Because of long commuting distances, almost all trips are motorized: cars (86%), trains (9%) and intercity buses (5%). Many PT trips involve either park-and-ride or kiss-and-ride (65%) in the home country, leaving a mere 27% access to active modes and 8% to city buses to access the departure station. Important differences in mode shares occur among home countries of cross-border workers (see the figure below) as well as between work places, a large proportion of PT users going to Luxembourg City (see the map below).

Thanks to improvement of rail and intercity bus services, PT ridership rose from 2007 to 2010, leading to an estimated increase of train passengers (+3,200) and bus riders (+4,300). Nevertheless, using the car for commuting is still highly dominant among the cross-border workers despite a fast decrease from 91% to 86% between 2007 and 2010.

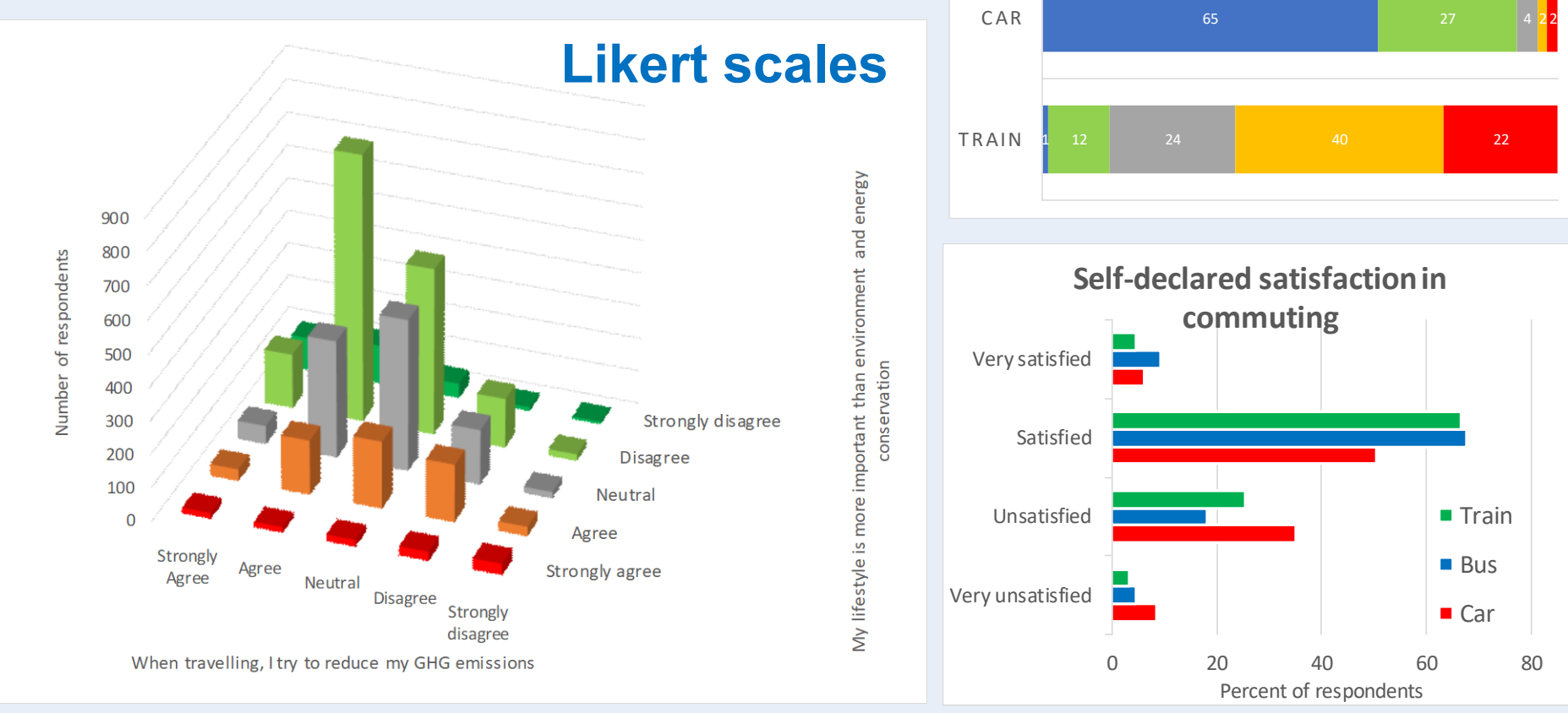
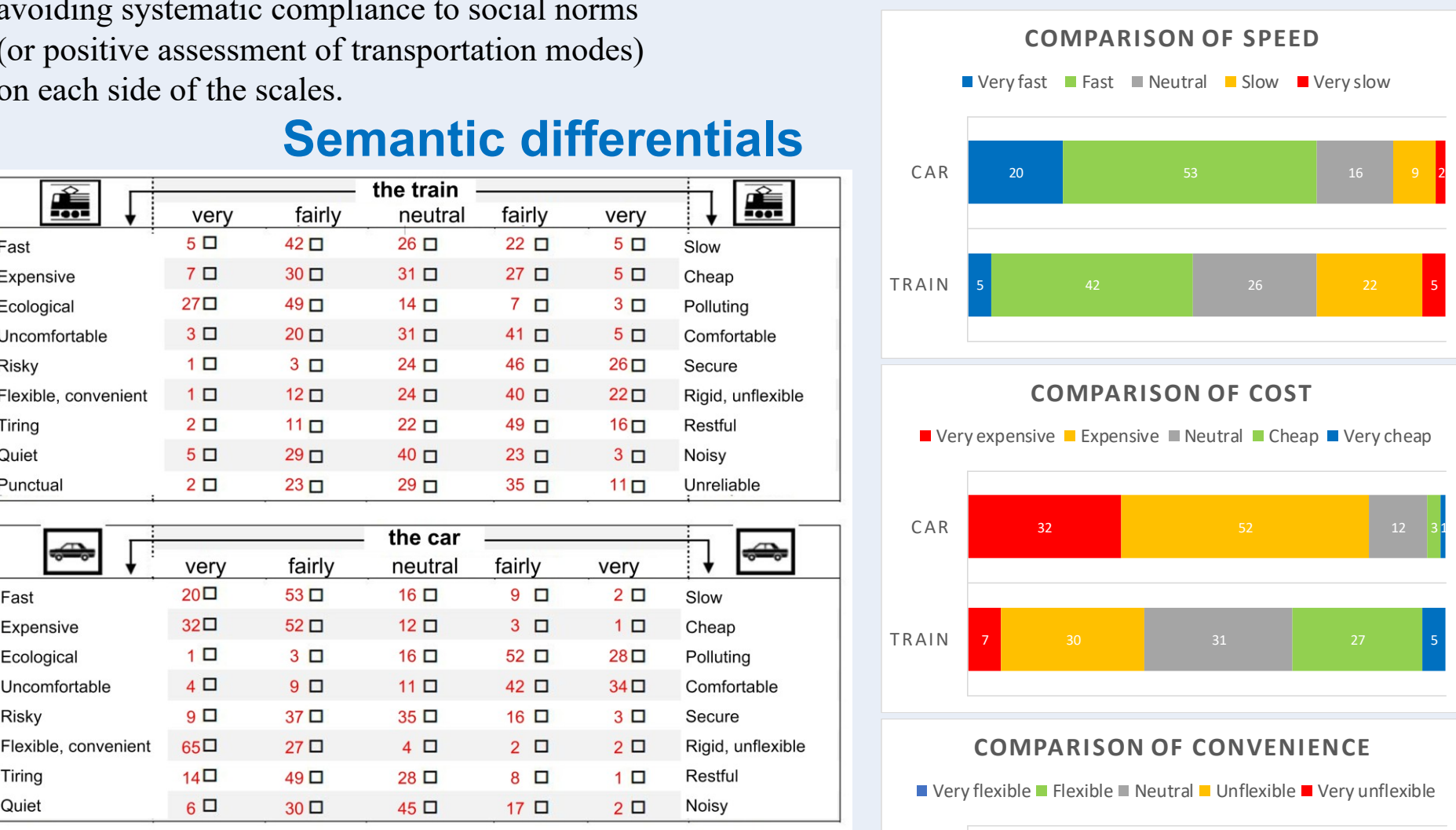


The recent evolution of mode shares increases relevance of modelling the influence of attitudes and beliefs on commuting choices. However, attitudes were surveyed only once, in 2011, impeding a longitudinal approach that had been preferred and limit our analysis to a cross-sectional view of the link between attitudes and commuting modes.

Several types of measurement instruments were used to allow for maximum flexibility in the assessment of concerns about the environment and beliefs about energy conservation (5-point Likert scales, see the figure below for an example), perception of suitability, reliability and efficiency of transport modes (semantic differential scales, see the figure below), satisfaction in commuting and travel (4-level bipolar scale, see the figure below), pull factors to use public transit (dummies), etc. Additional qualitative assessments were coded using semantic associations (keywords).

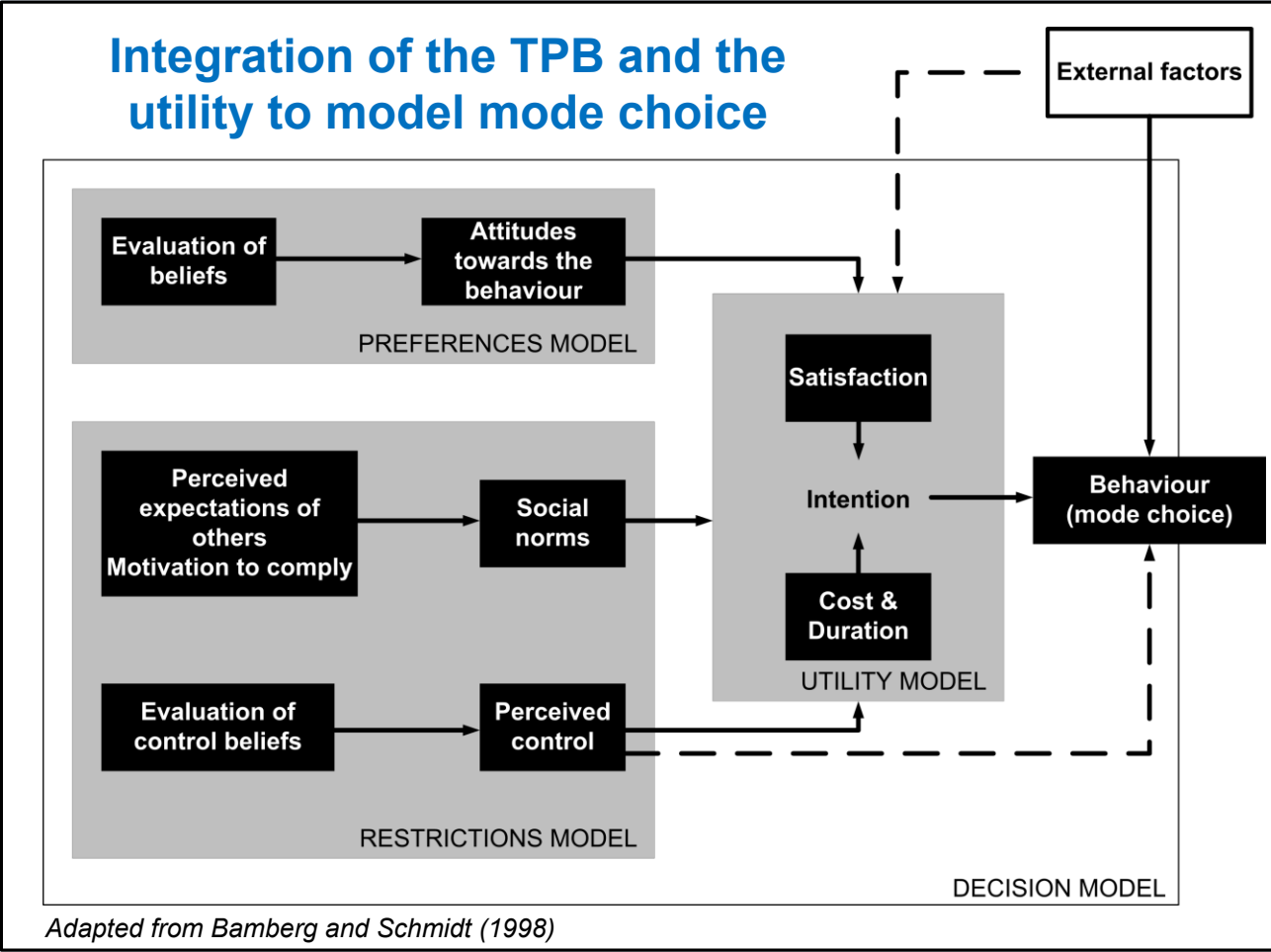
Semantic differential scales permit direct comparison of the car and the train using several criteria as illustrated in figures below for the speed, the cost and the convenience of both transportation modes.

It is noteworthy that self-reported satisfaction in commuting is globally higher among the PT users than the car drivers, which implies a positive appreciation of PT supply and/or some congestion on the motorway network at peak hours. Moreover, use of PT modes and satisfaction of bus and train service is unequal among countries, meaning different levels of service that should be coordinated with the Luxembourg PT supply.



### Attitudes, Beliefs and the Theory of Planned Behaviour

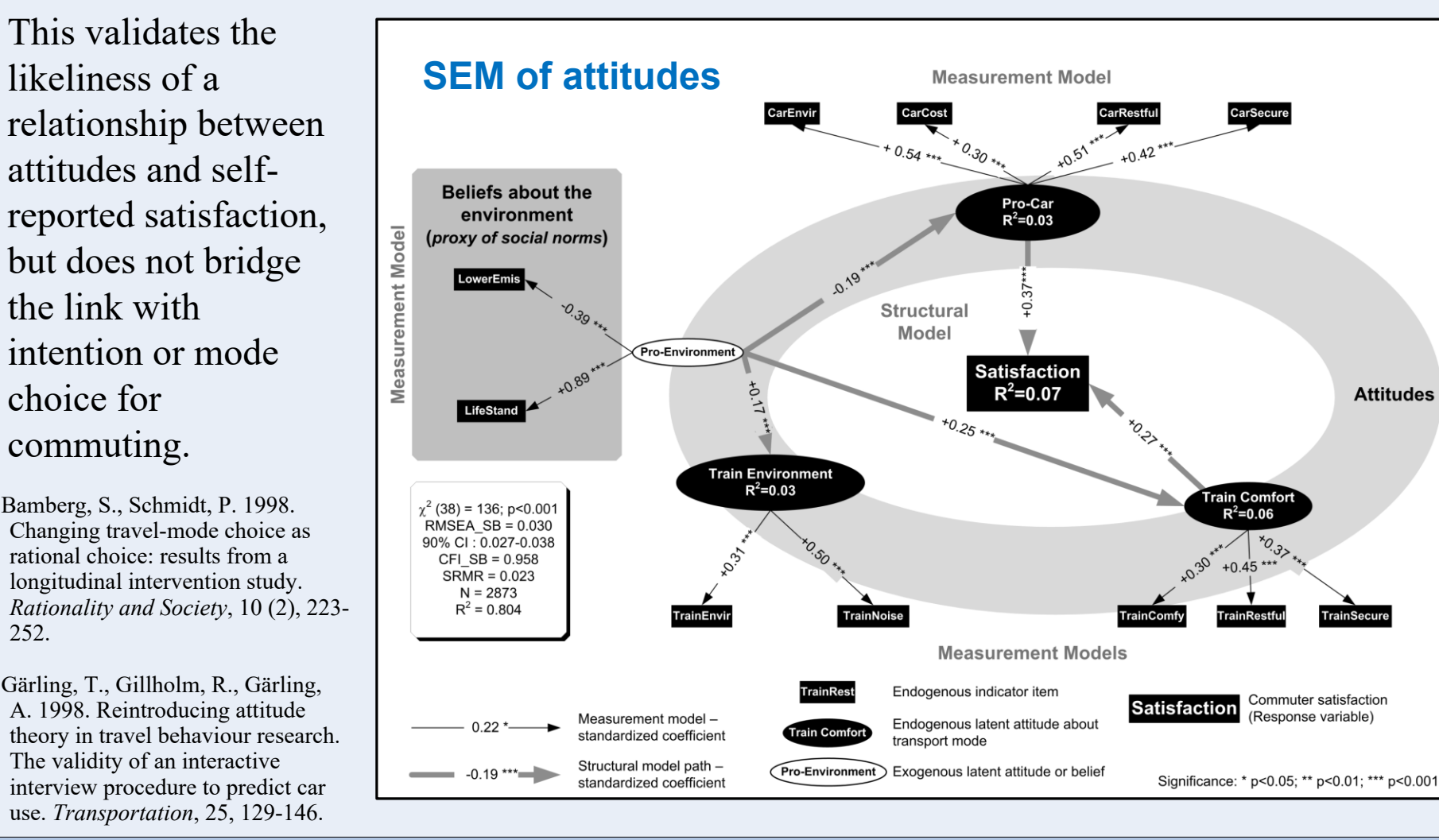
The TPB provides a rational actor theory to model intention that leads to choices. It includes a preference model to mediate the impact of beliefs using attitudes towards behaviour (ATB) and a restriction model to mediate both social norms and control beliefs on perceived expectation of others and perceived control towards intention and the actual behaviour (e.g. mode choice). Bamberg and Schmidt (1998) extended the TPB with a utility model that can handle the usual economic view of travel cost and duration. As satisfaction is a long-term mediator of ATB, we further extend this utility model to include self-declared satisfaction in travel to define a latent factor of the perceived utility that mediates the impact of preferences, restrictions and satisfaction towards behaviour and, in this case, commuting mode choice.



Satisfaction is needed when dealing with repeated "choices" like daily commuting because the impact of attitudes and controls evolve with experience and habits, eventually leading to routine that highly condition the outcome (Gärling et al. 1998), while accumulation of unsatisfactory experience could lead to change of habits.

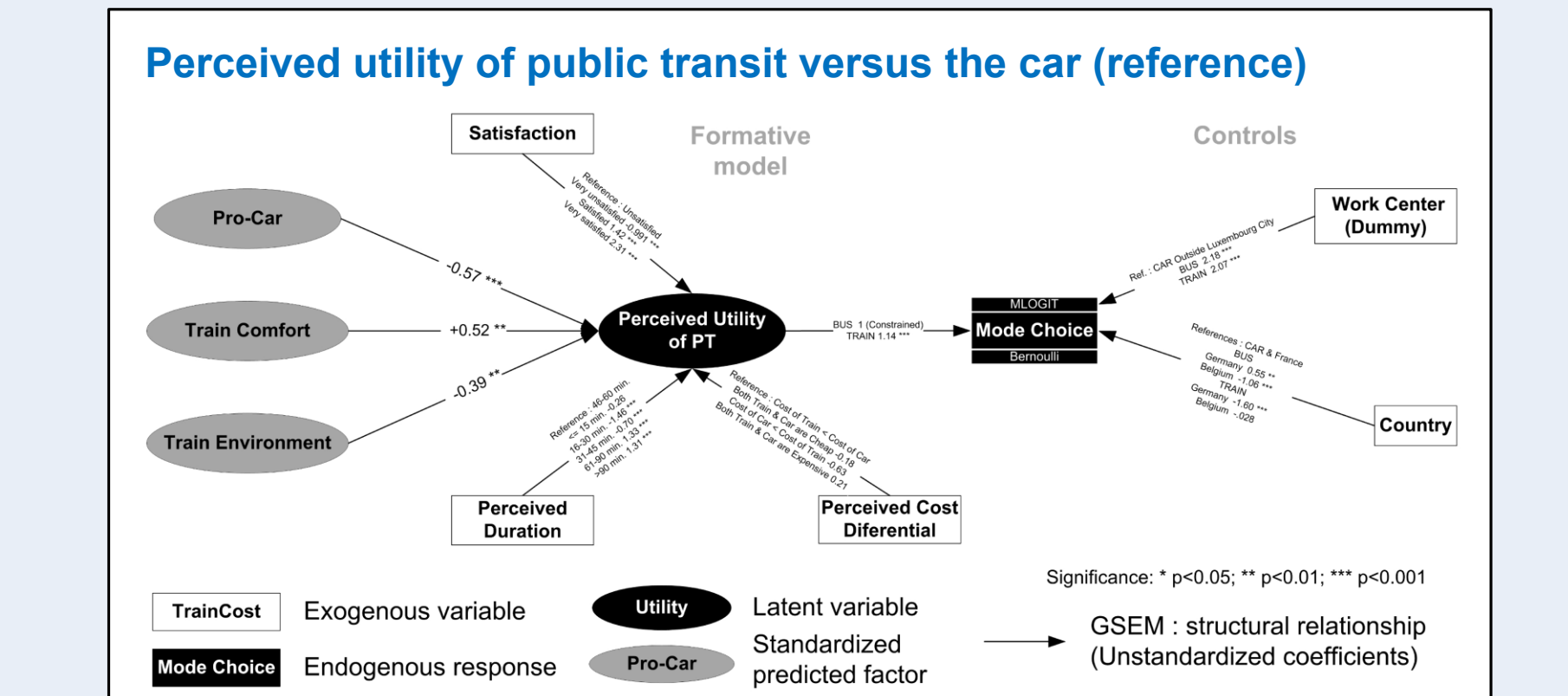
Confirmatory factor analysis (CFA) was used to summarize semantic differential scales using indicative variables and define latent variables of attitudes related to appreciation of the car and the train. Factors scores of measurements models provide a continuous assessment of preconceived constructs based on the correlation of measurement indicators keeping their common signature (congruence) and cutting off disparities in error terms. This procedure yielded 3 attitude factors: 1) the pro-car attitude (PCA); 2) the train comfort appreciation attitude (TCA); and, 3) a train environmental friendliness attitude (TEA).

The figure below shows an improved setting of these attitudinal factors using SEM to add two Likert scales on environmental beliefs to define a Pro-environment attitude (PEA) that influence the attitudes about transport modes. It uses self-declared satisfaction of commuters to further calibrate the definition of attitudinal factors. The main benefit of this model is to provide a preliminary estimate of four latent attitudinal constructs (PEA, PCA, TCA and TEA) considering their mutual links, thanks to the capacity of SEM to properly handle endogeneity.

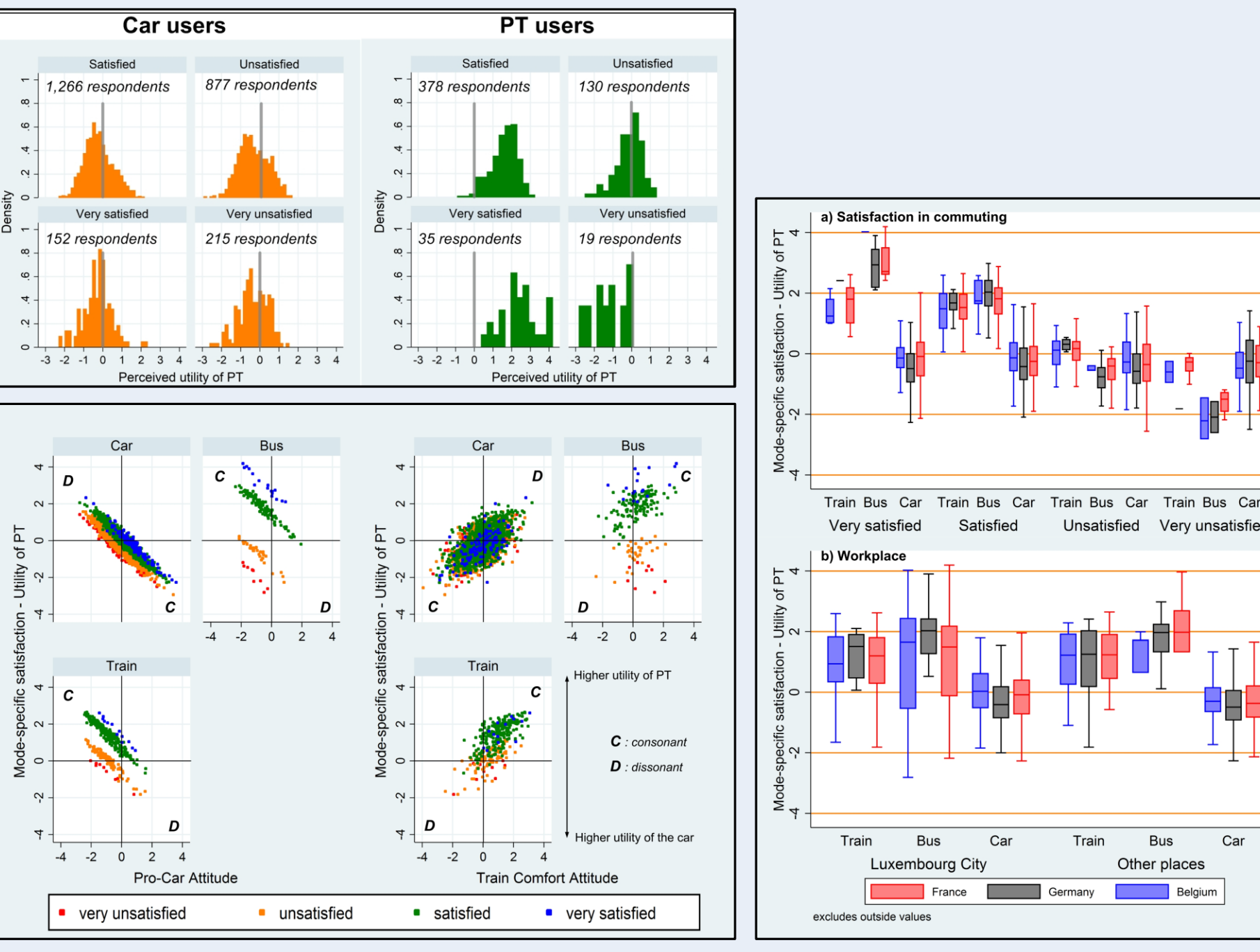


### Modelling the Perceived Utility

The concept of utility is central to the transportation literature, considering the cost and duration of travel (and value of time) to compare modes. During the last decades, progress was made using multiple ways to integrate attitudes and socio-psychological context within various functional specifications of logistic regression and SEM. This integration could be made by integrating the attitudes in the specification of the utility assuming their role in the shaping of the utility because attitudes about transport modes are qualitative assessments of their suitability to support travel needs. The figure below shows a SEM model of perceived utility of PT that integrates attitudes, self-reported satisfaction, travel cost and duration with the mode choice as the outcome (multinomial logit). For the specific case of Luxembourg, countries and the location of the work place are used to control for the eventual bias of differences in PT service levels.

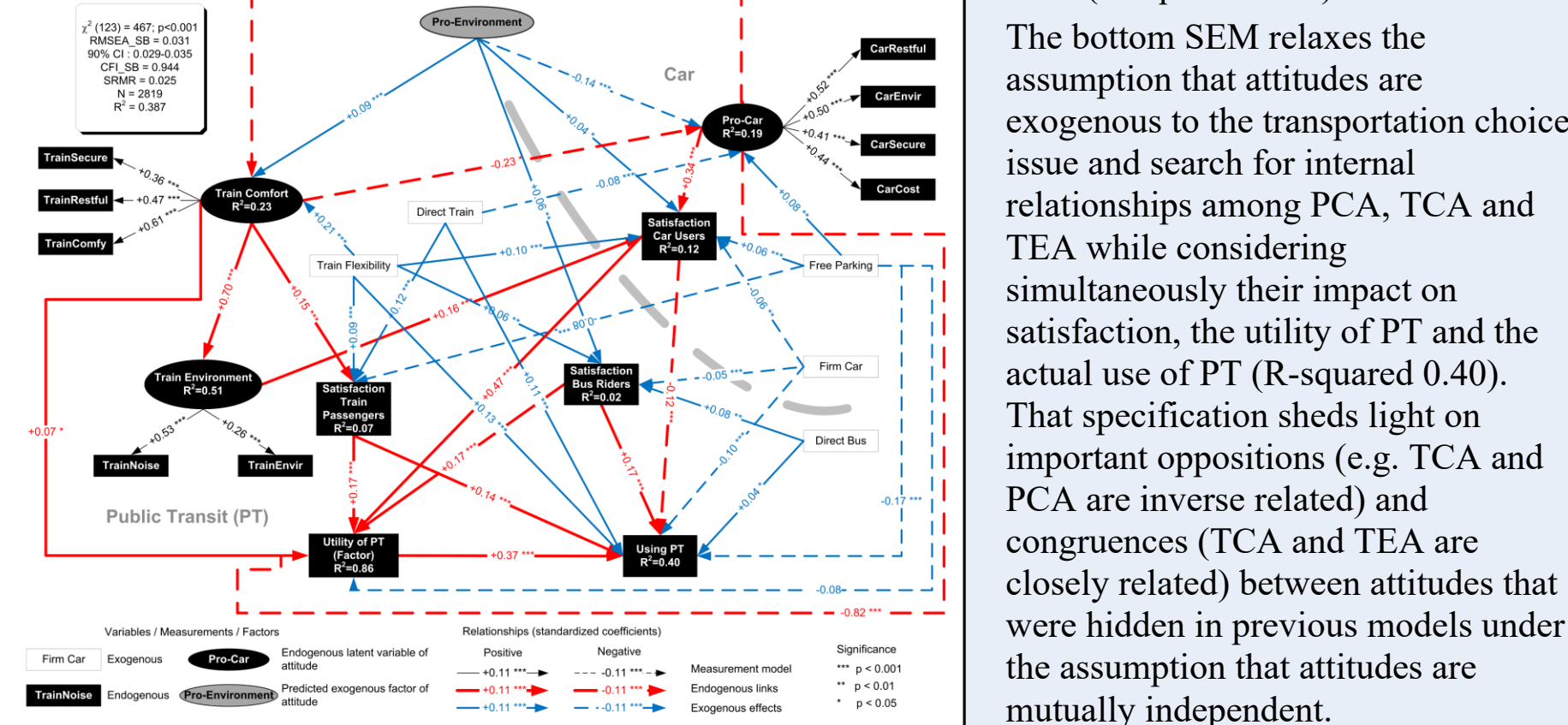
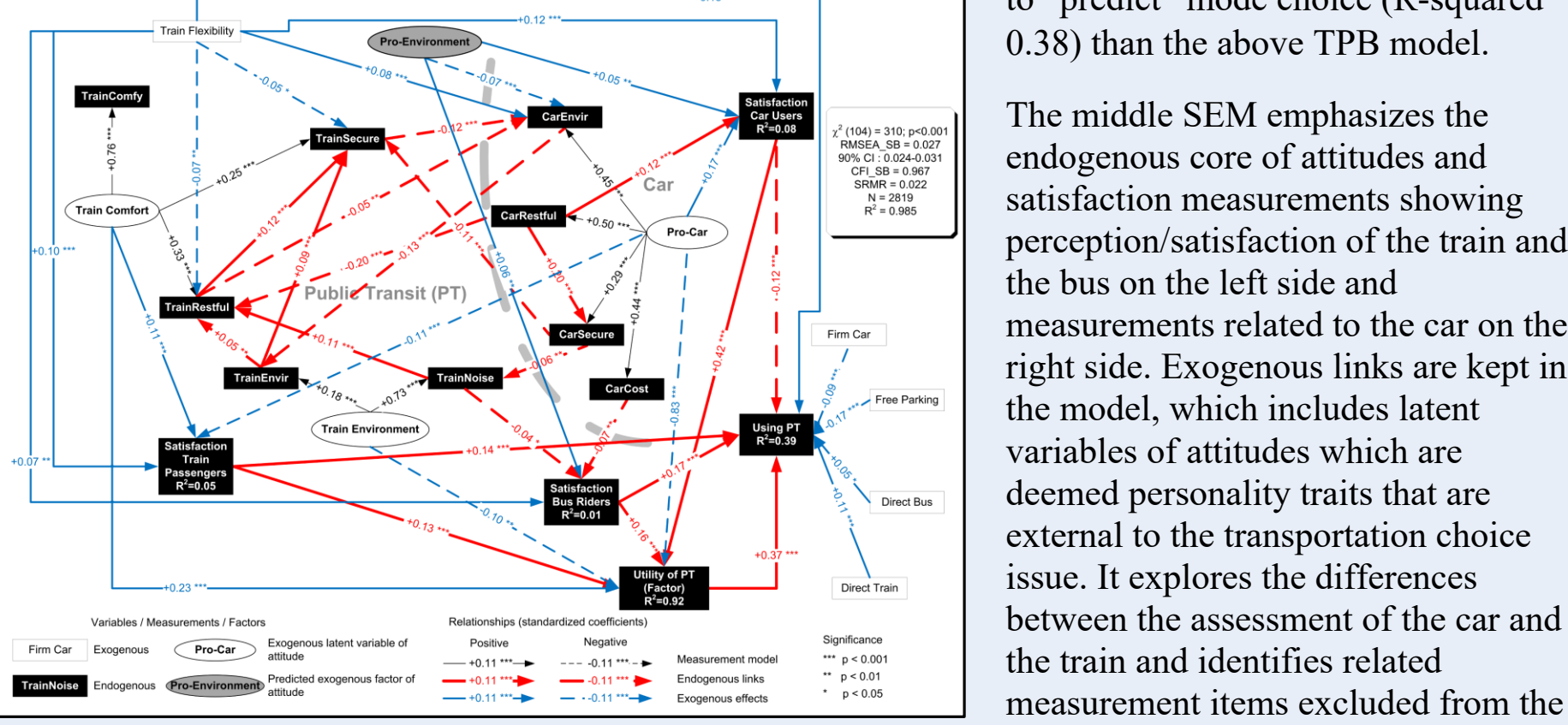
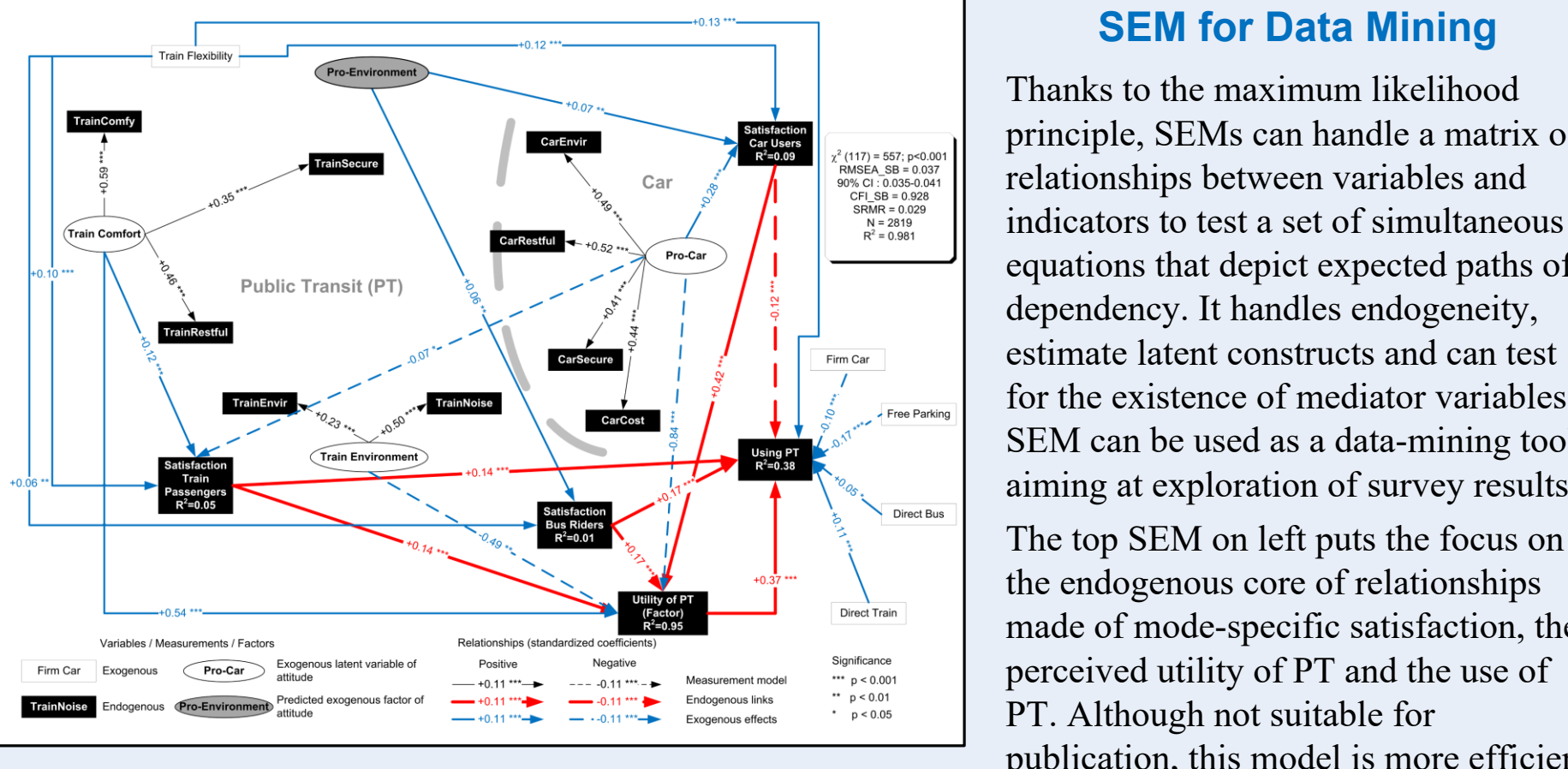
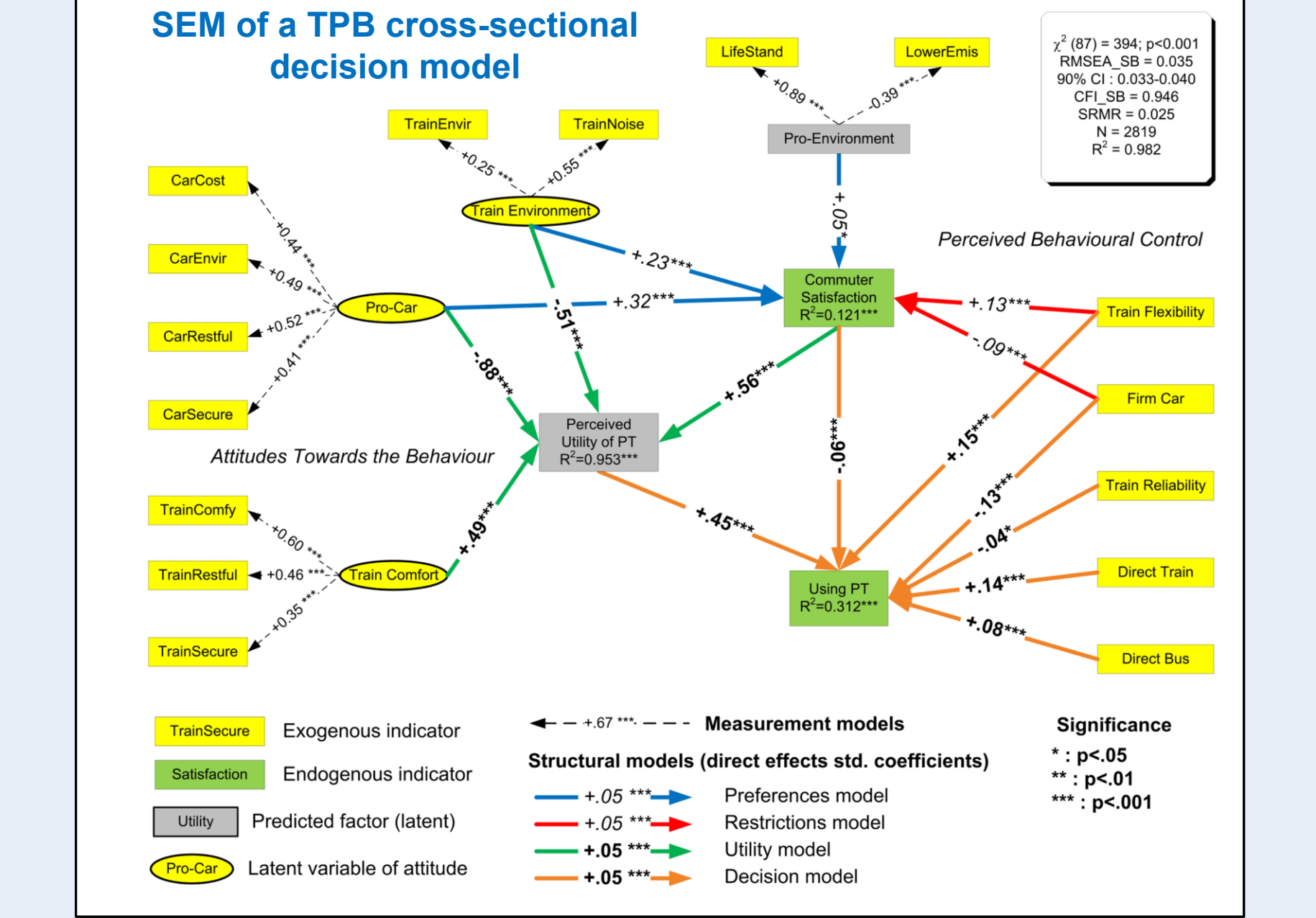


Figures below show the distribution of values on the perceived utility of PT according to mode choice, self-reported satisfaction in commuting, PCA, TCA and home country. They illustrate the efficiency of controls in the utility model, the relevance of considering satisfaction when modelling a long-term habit (sometimes choice) like commuting and its potential for analyzing congestion / dissonance between attitude factors, the perceived utility and the mode used.



### Cross-sectional Decision Model and SEM for Data Mining

Previous models provide the latent and predicted attitudinal factors needed to implement the conceptual framework of the TPB. The figure below presents an example of the integration of attitudes (PCA, TCA, TEA and PEA), the perceived utility of PT and self-declared satisfaction in commuting to model the use of PT for commuting. It is a simple and preliminary simultaneous integration of the four models of the TPB. Its overall adjustment to the survey data is fairly good (CFI=0.946; RMSEA=0.035; SRMR=0.025; R-squared 0.312), advocating for the usefulness of the extended framework of TPB. External factors provided by the survey are used to specify a restriction and a decision model. They are a combination of latent factors and self-reported status of PT service at the work place and access to a dedicated firm car.



### Discussion and Conclusion

CFA and SEM allowed us to develop latent variables to disentangle intertwined relationships between beliefs, perceptions and attitudes and identify mediators (satisfaction and perceived self-utility) to relate them to the choice of PT in commuting based on the TPB. SEM approach could be used as a data-mining tool to gain in-depth knowledge of relationships among survey measurement items and improve model specification. The bottom figure illustrates the final outcome of the data mining: an enhanced SEM (R-squared=0.449) that is far better fitted than the initial TPB model shown above.

The analysis procedure leads to identification of strengths and weaknesses of the Luxembourg survey.

- Strengths**
  - A broad set of measurement scales (Likert, semantic differentials, satisfaction levels, dummies, keywords) to better specify the latent variables of attitudes, utility and perceptions
  - A large sample allowing to specify sophisticated models
  - Asking for self-reported satisfaction to enhance modeling of the perceived utility

- Weaknesses**
  - A very small set of Likert scale measurements of beliefs about energy and environmental concerns impeding CFA of the pro-environmental attitude
  - Pull factors for using PT rather than the car were coded using dummies that are unrelated and inappropriate to build latent variables (they should be replaced by 4-level semantic differentials: no effect, slight effect, important trigger, decisive)
  - Cross-sectional models are limited, and panel surveys are needed to enable longitudinal analysis of the feedback impact of satisfaction on attitudes

