Intention and utility: integrating models of daily mobility behaviours? The Luxembourg cross-border case study

Philippe Gerber[1-4], Marius Thériault[2], Samuel Carpentier-Postel[3], Christophe Enaux[4]

1 Liser – Luxembourg Institute of Socio-Economic Research (Luxembourg)
2 Université Laval, ESAD/CRAD, Québec (Canada)
3 Aix-Marseille Université, CNRS, UMR 7300 ESPACE (France)
4 Université de Strasbourg, CNRS, UMR 7362 LIVE (France)

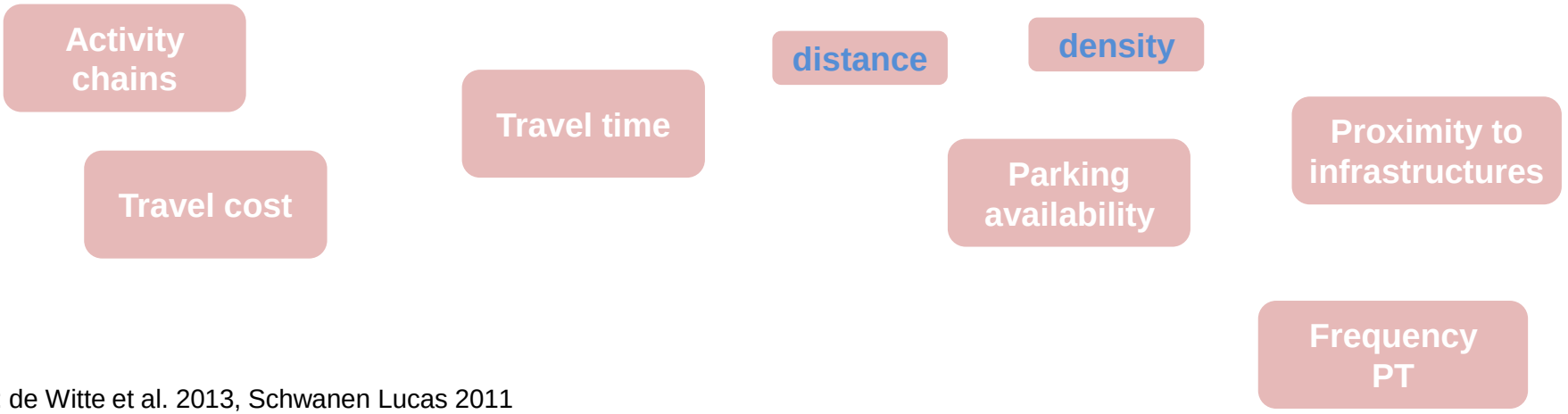
Presentation to Swiss Mobility Conference, Lausanne, Switzerland
October 20-21, 2016

Outline

1. Mode choice: Main theoretical approaches and determinants
2. Methodological framework: SEM and GSEM
3. Application : the cross-border workers (CBW) of Luxembourg
4. Discussion and perspectives

1. Mode choice

- **4 main theoretical approaches**
  - Time Geography (Hägerstrand 1970, Lenntorp 1976…)
    - Accessibility is the key concept (linked to travel time & cost, transport mode, land use and urban structure, activity chains…),
    - Complementary to 4-steps modeling
    - but no real explanatory modeling.



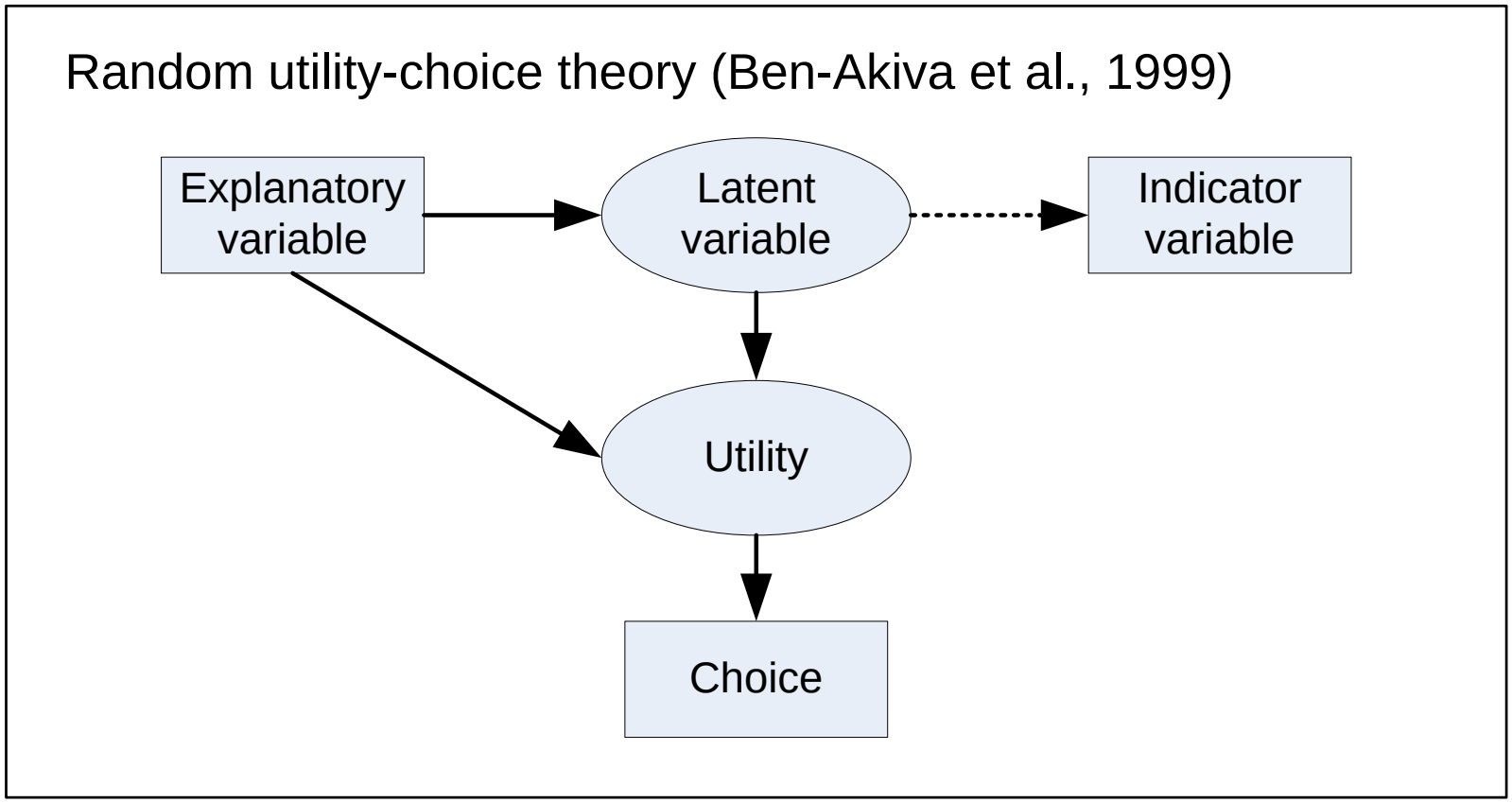
Sources: de Witte et al. 2013, Schwanen Lucas 2011

1. Mode choice

- **4 main theoretical approaches**
  - Time Geography
  - Utility theory approaches (Ben Akiva & Lerman 1985…):
    - characteristics of the alternatives (OD travel time & cost, flexibility),
    - characteristics of the decision-maker,
    - characteristics of the situation (density…),
    - but imperfect information, forget the symbolic and affective motivations, etc.

Sources: de Witte et al. 2013, Faivre d'Arcier 2008, Schwanen Lucas 2011

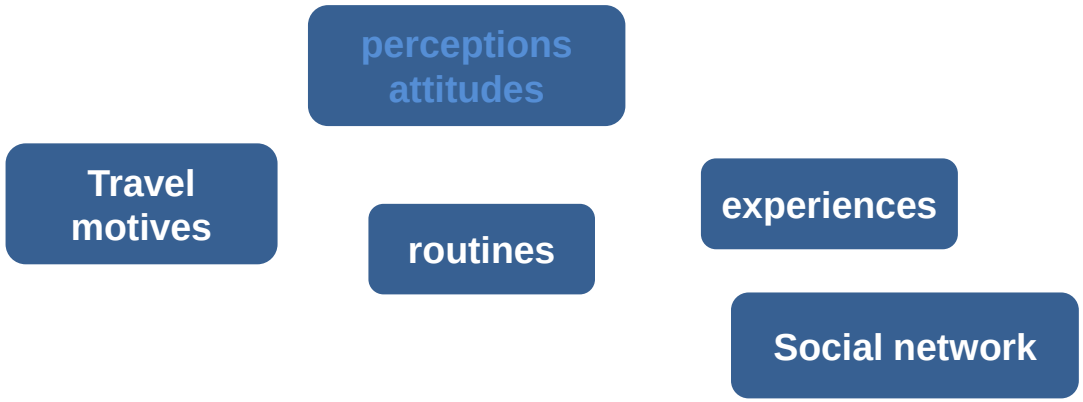
Example: Random utility and choice-making theories



An econometric vision of choice / decision making – e.g. discrete choice models

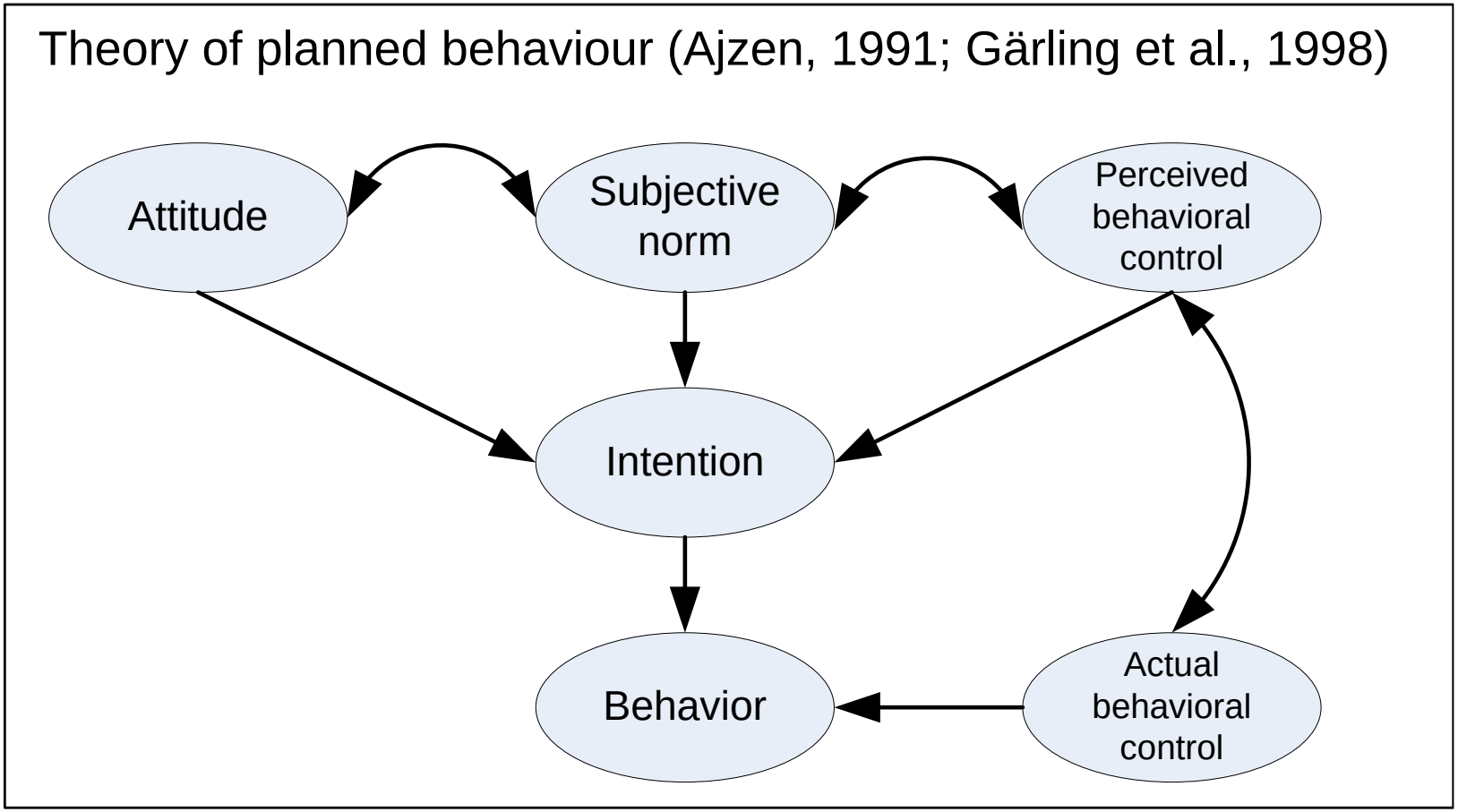
1. Mode choice

- **4 main theoretical approaches**
  - Time Geography
  - Utility theory approaches
  - Socio-psychological theories (Azjen 1991, Triandis 1977, Schwartz 1977…)
    - adress the impact of attitudes… in a theoretical and explicit manner,
    - external preconditions,
    - habits, trajectories and changes more included.



Sources: de Witte et al. 2013, Schwanen Lucas 2011

Example: Theory of planned behaviour



E.g. a social psychological point of view on transportation mode choice

1. Mode choice

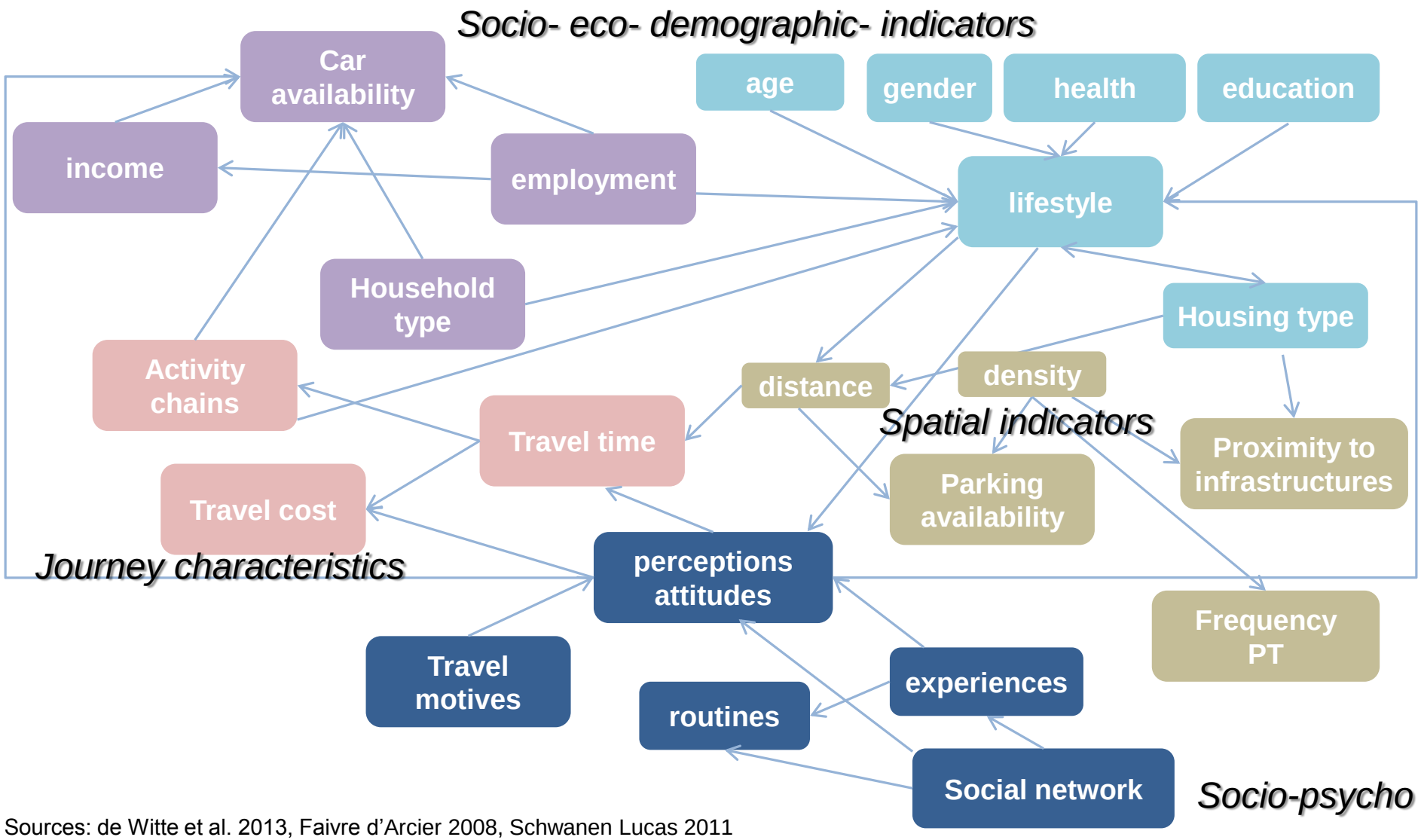
- **4 main theoretical approaches**
  - Time Geography
  - Utility theory approaches
  - Socio-psychological theories
  - Mobility turn (Urry 2000, Cresswell 2010…)
    - system dynamics linked to culturally and networked people, objects, ideas, knowledge, emotions,
    - identity and lifestyles intertwined,
    - motility (access, skills and cognitive appropriation).

- **How would we combine these approaches in order to focus especially on transport mode choice behaviour?**

Sources: de Witte et al. 2013, Schwanen Lucas 2011

1. Mode choice

- **4 main types of determinants**

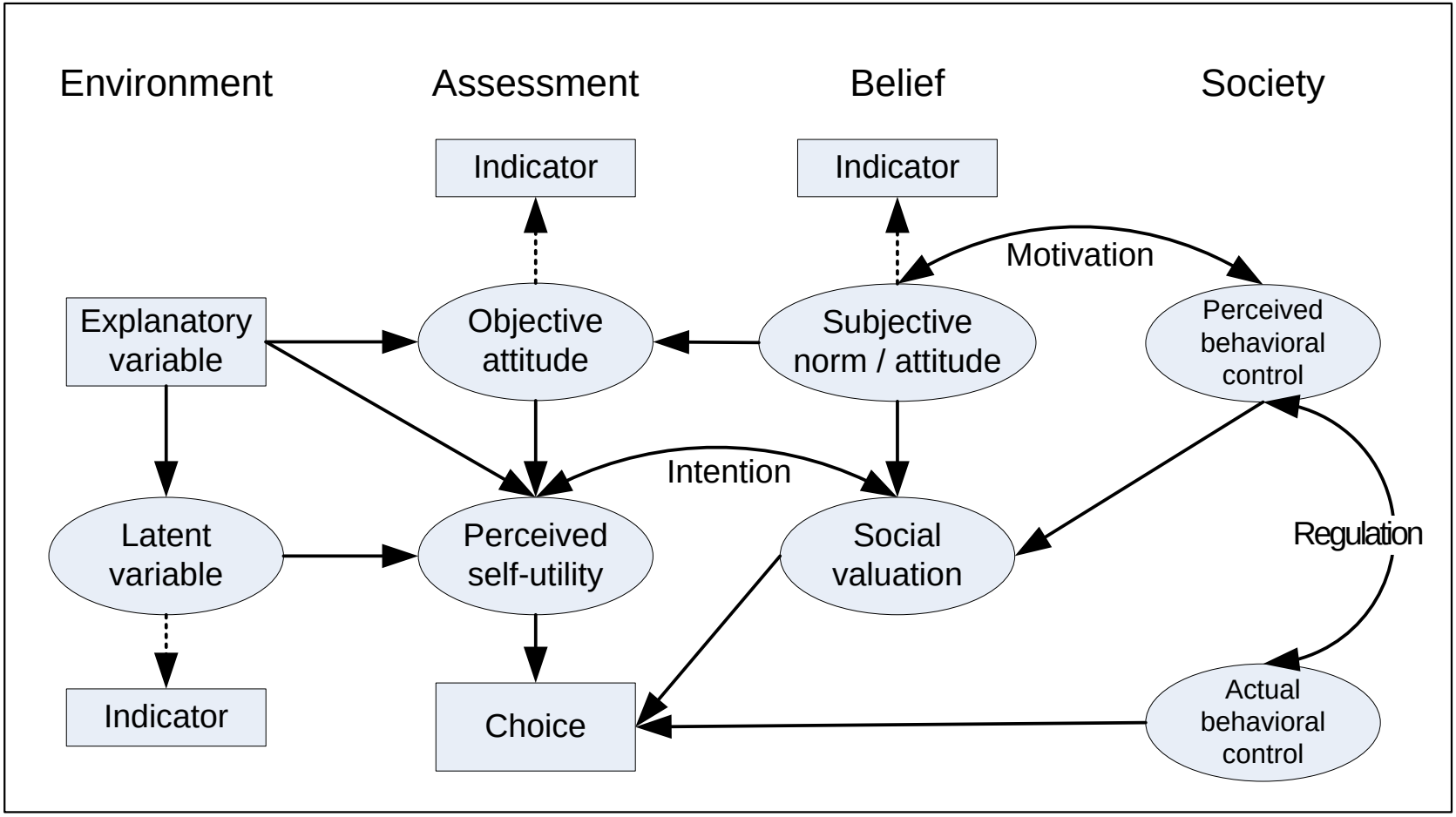


Sources: de Witte et al. 2013, Faivre d'Arcier 2008, Schwanen Lucas 2011

1. Mode choice

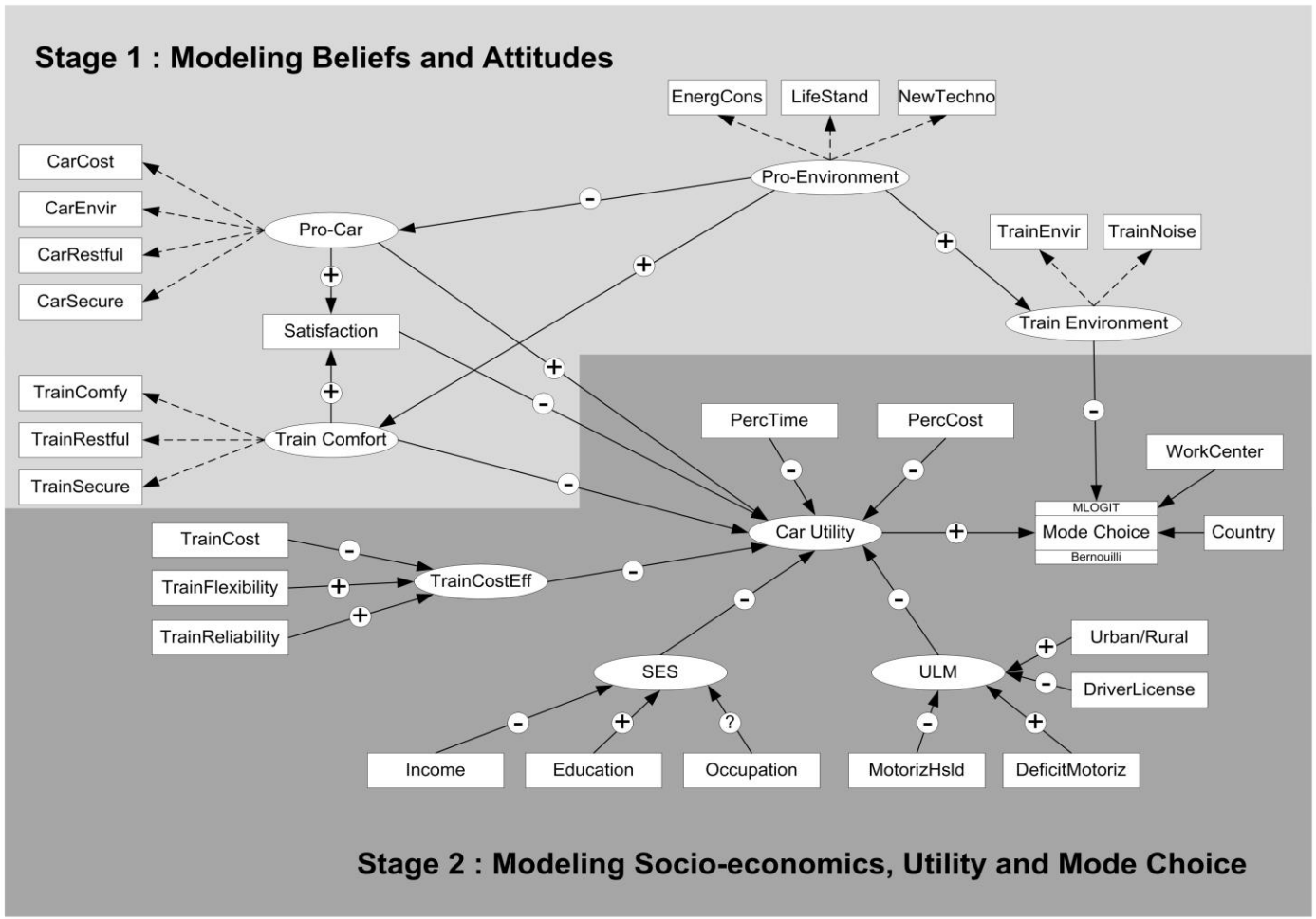
- **A hybrid position:**

  an integrated socio -psycho and -economic framework



2. Methodological framework: SEM and GSEM

Beliefs, attitudes, perceived self-utility and social valuation (2 stages)



Hypotheses:

1) This specification is *adequate* and globally fit empirical data collected during the mobility survey

2) *Commute satisfaction and mode choice are driven by intentions that could be modeled as a multi-dimensional combination of : i) perceived self-utility of using a car vs PT and ii) a social valuation reflecting subjective attitudes*

2. Methodological framework: SEM and GSEM

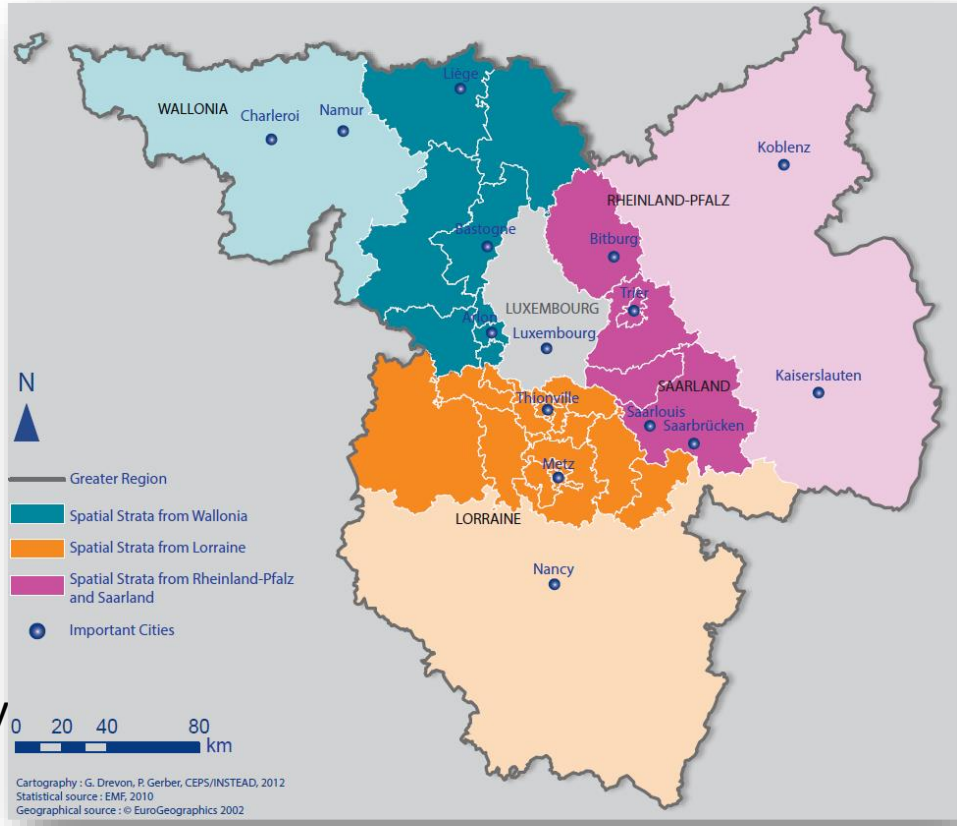
- Main differences with usual statistics
  - Using an explicit conceptual framework (management of constraints)
  - Better control over functional forms (flexible specification) and on fit procedures
  - Explicit management of endogeneity and mediation
  - Several equations solved at once (simultaneous)
- Complex phenomena (~ difficult to measure)
  - Structural complexity (multidimensional), Needing instruments (latent variables)
  - Modelling complex systems dynamics
- Application domains
  - Psychology (e.g. attitudes, beliefs), Sociology (e.g. innovation, segregation)
  - Economics (e.g. utility, market segment.), Transport (e.g. route/mode choice)
  - Geography (e.g. spatial cognition, perception), Political Science, Etc.

2. Methodological framework: SEM and GSEM

- Elements of a structural model
  - Measured variables and indicators
  - Latent variables (concept without simple measurement)
  - Relationships (covariance) and correlations
  - Correlation paths and simultaneous equations
  - Endogenous variables
  - Exogenous variables
  - Dependent variables (response/outcome)
  - Mediators
  - Direct (partial), indirect and total effects
  - Multiple error terms and variance of errors
  - Covariance among variables and error terms
  - Management of constraints and parameters
  - Assumptions and Tests of hypotheses
- Two synthesis approach
  - Reflexive modelling : Confirmatory Factor Analysis (CFA)
  - Formative modelling : structural models (SEM or GSEM) with one or several response variables (outcome)

3. Application: the CBW of Luxembourg

- Survey in France, Belgium, Germany
- 2010 (classical mobility behaviour survey) and 2011 (perceptions, beliefs and values)
- 7,225 (R.R. >18%) et 3,727 (R.R. 52%) respondents
- Self-answered questionnaire (sent by mail) based on a spatial stratified representative sampling
- Themes: household structure, employment, agenda + flexibility, daily travel, commutes, parking, housing choices, perception of car and train, satisfaction, environmental beliefs, energy conservation, change incentives, etc.



- Published results in: Schmitz et al. 2012 (descriptive), Enaux and Gerber 2014 (attitudes/beliefs towards energy), Ma et al. 2015 & Schiebel et al. 2015 (mode choice), Drevon et al. to appear (spatial integration & activity patterns)

3. Application: the CBW of Luxembourg

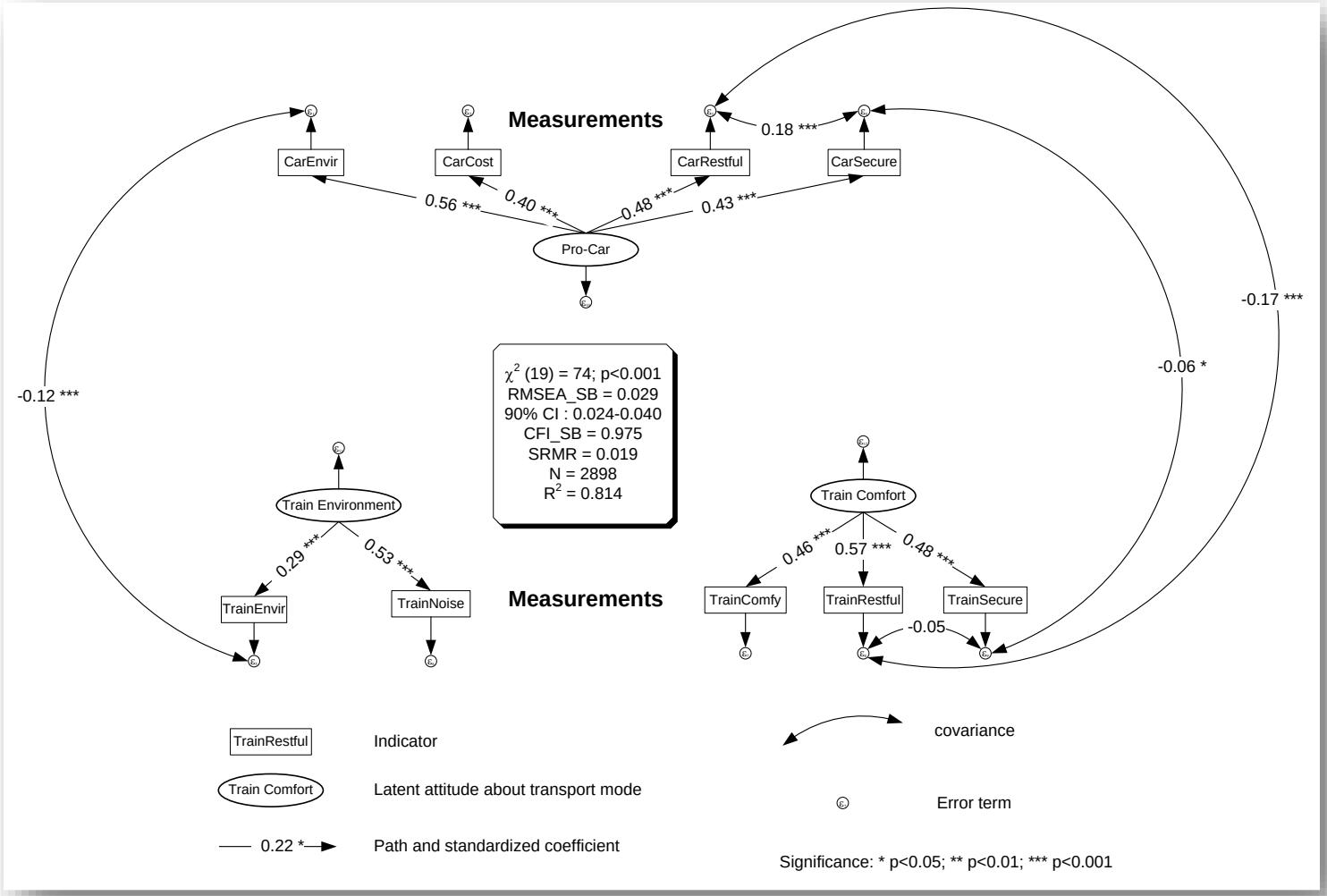
Confirmatory Factor Analysis (1)

- Main differences with factor analysis (e.g. PCA…)
  - Not only driven by mathematical criteria (e.g. decreasing eigenvalues)
  - Request explicit identification of target factors and to identify indicators to combine (not exploratory)
  - Admission that each indicator contains errors that should be removed (pushed in error terms)
  - Factors are future latent variables to “explain” after mode choice
  - Yield factor scores distributed on a continuous bipolar measurement scale

  - **Reflexive synthesis of data**

3. Application: the CBW of Luxembourg

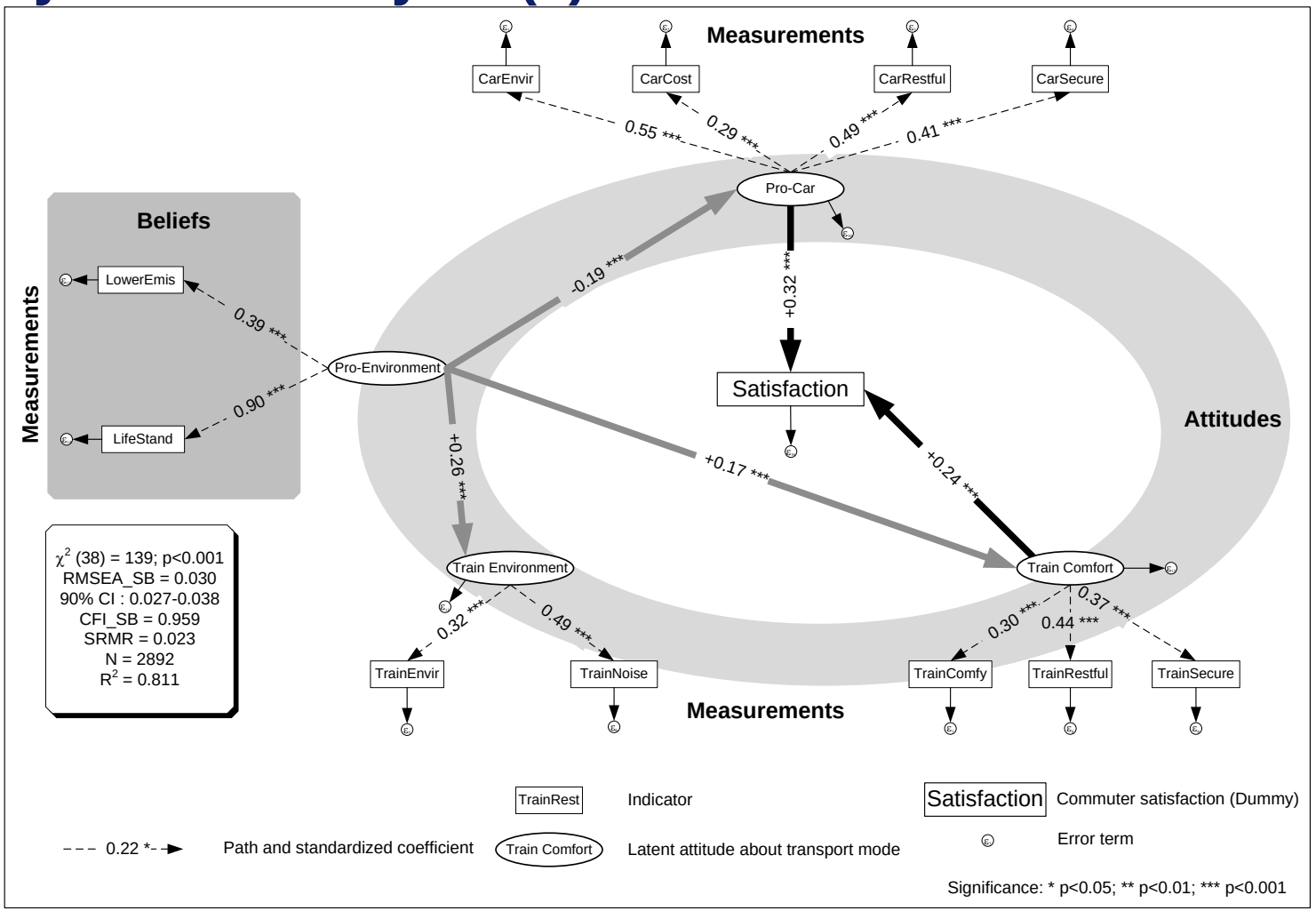
Confirmatory Factor Analysis (2)



Intensity & significance of relationships, covariance between error terms and 3 fit indexes – absolute/relative (RMSEA, CFI, SRMR…)

3. Application: the CBW of Luxembourg

Confirmatory Factor Analysis (3) and SEM

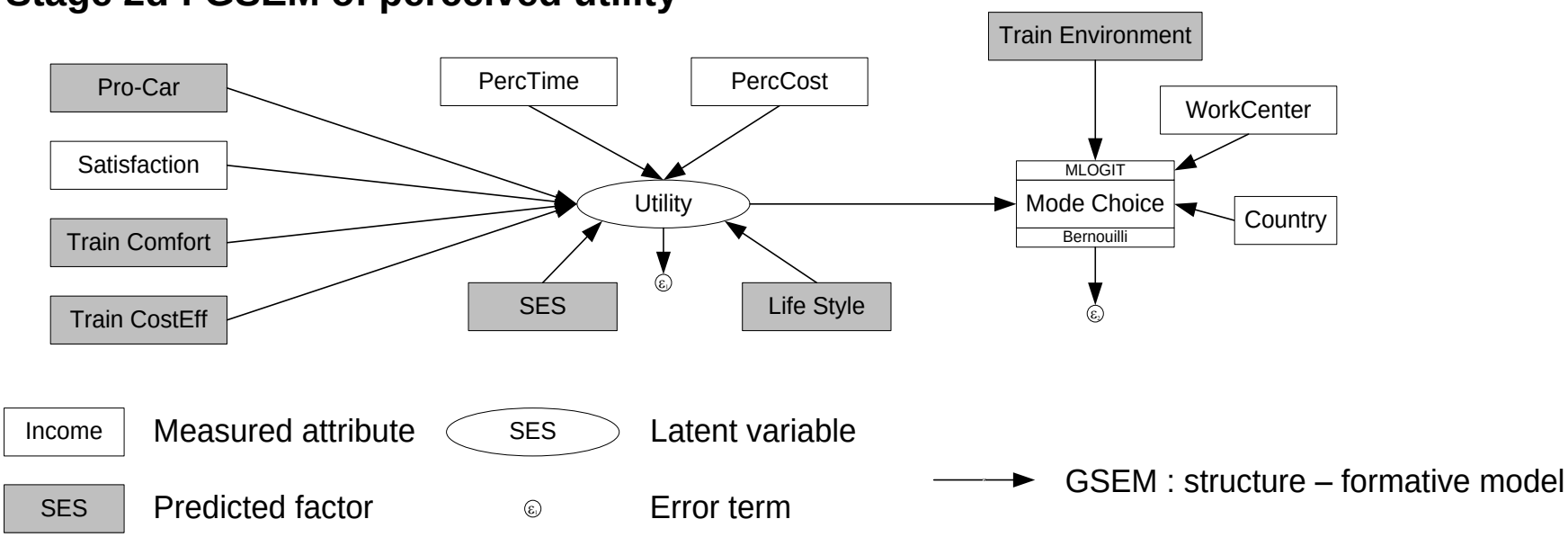


Relationship between attitudes with formative calibration to explain a feeling (Satisfaction → response to attitudes)

Model using several simultaneous equations for integration (here 15)

3. Application: the CBW of Luxembourg

Example of GSEM and formative model (stage 2d)

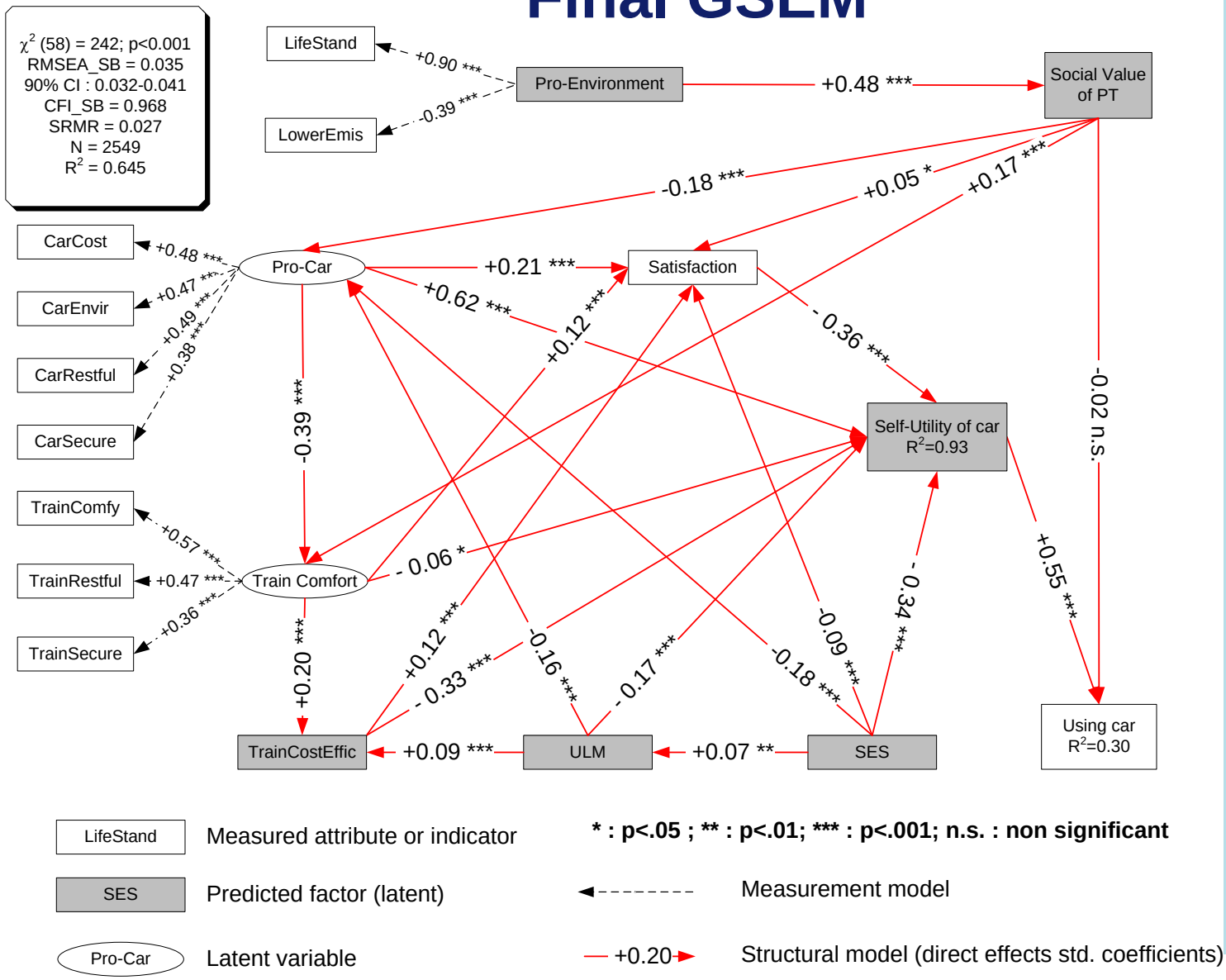


A complex case : perceived self-utility (S-U)

- Integrate measurements (time, cost, satisfaction) and predicted factors (attitudes, socio-economic status, cost-efficiency assessment for train)
- 2 equations : one to assess S-U (continuous); one to calibrate its impact on mode choice (multinomial) with application of fixed and random effects
- 2 error terms (latent variable + response variable or « outcome »)

3. Application: the CBW of Luxembourg

Final GSEM



Good fit – validate linkage between attitudes → perceived S-U. Signs are in line with expectations.

Social valuation of PT increases satisfaction in commuting and decreases perceived S-U of car.
SES and ULM exert direct influence on S-U, and lowers PCA.
Objective attitudes exert a stronger influence than subjective ones and beliefs

Discussion

- Hybrid theoretical model in order to link TPB and RUM and main determinants of mode choice (beliefs, attitudes, socio-economics & demographics, satisfaction, some spatial indicators)
- (G)SEM are i) complementary to other statistical techniques, ii) can handle complex phenomena in comparing concepts with empirical data (measured and latent), iii) master multicollinearity, endogeneity and iv) relax several other assumptions (orthogonality…)
- The model explores the relationship between pro-environmental beliefs and attitudes about transport modes:
- **Intentions impact decision making, and mode choice is multidimensional**! Examples:
- Beliefs exert a less influence than comfort and efficiency of transportation when mediated by S-U and social valuation.
- Increasing flexibility of PT has a stronger effect on train attractiveness than lowering its cost.

Perspectives

- Attitudes are not independent: the geographical and social context influence the results (spatial indicators): Going further in the urban constraints' measurements (as accessibility alternatives, etc.) in order to evaluate / mediate the attitudes' effects
- Difficulty to reach / measure the social norms in the social valuation, especially regarding 3 different countries/regions (not in the CB mobility survey): Trying to compare social / institutional norms from the 3 countries in order to better control this (macro) effect
- Mobility biographies (Lanzendorf 2003, Scheiner 2007…) as an assessment of residential move and potential changes in daily mobility

LISER
LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

swiss mobility conference

Thank You for your attention!
Questions?

Philippe Gerber[1-4], Marius Thériault[2], Samuel Carpentier-Postel[3], Christophe Enaux[4]

1 Liser – Luxembourg Institute of Socio-Economic Research (Luxembourg)
2 Université Laval, ESAD/CRAD, Québec (Canada)
3 Aix-Marseille Université, CNRS, UMR 7300 ESPACE (France)
4 LIVE UMR 7362, Université de Strasbourg-CNRS (France)

Presentation to Swiss Mobility Conference, Lausanne, Switzerland
October 20-21, 2016

Examples of Latent versus Measured Variables

Latent	Definition	Direction (+)
Pro-Environment	*Pro-environmental general attitude (reflective of beliefs)*	Pro-environment
Train Environment	*Attitude about environmental impact of trains (reflective)*	Train is clean
Pro-Car	*Attitude about cars (reflective)*	Car is appreciated
Train Comfort	*Attitude about comfort and security in trains (reflective)*	Train is comfortable
Train Cost-Efficiency	*Assessment of train cost-efficiency (formative)*	Train is efficient
SES	*Respondent's socio-economic status (formative)*	Higher Education
ULM	*Urban home place, low motorization (formative)*	Urban lower motoriz.
Utility	*Comparative utility of car versus public transport (formative)*	Car is most useful

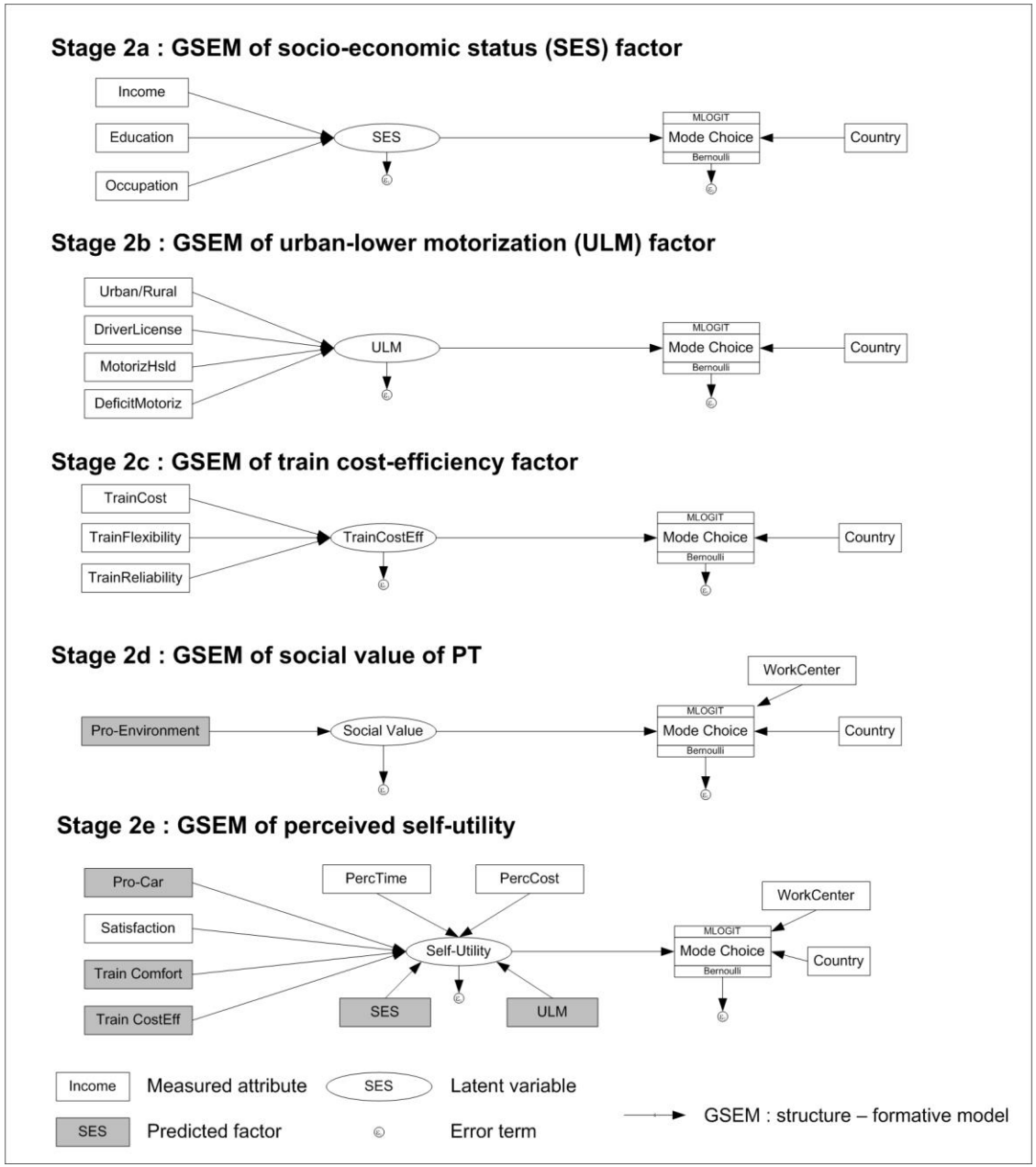
Measured	Description	Measurement	Scale
Assessment of the train (Indicators)			
TrainComfort	*Comfort in the train*	Very uncomfortable to very comfortable	[1..5]
TrainRestful	*Restfulness in the train*	Very tiring to very relaxing	[1..5]
TrainSecure	*Security in the train*	Very risky to very secure	[1..5]
TrainEnvir	*Environmental impact*	Very polluting to very clean	[1..5]
TrainNoise	*Train noisiness*	Very noisy to very quiet	[1..5]
TrainCost	*Cost of the train*	Very expensive to very cheap	[1..5]
TrainFlexibility	*Train Flexibility*	Very rigid to very flexible	[1..5]
TrainReliability	*Train Reliability*	Very unreliable to very punctual	[1..5]

Latent Variables (examples)

Table 1. Specification of latent variables (continuous)

Name	Definition	Direction (+)
Pro-Environment (PEA)	Pro-environmental general attitude (reflective of beliefs)	Pro-environment
Train Environment (TEA)	Attitude about the environmental impact of trains (reflective)	Train is clean
Pro-Car (PCA)	Attitude about cars (reflective)	Car is appreciated
Train Comfort (TCA)	Attitude about comfort and security in trains (reflective)	Train is comfortable
Train Cost-Effectiveness (TCE)	Assessment of train cost-effectiveness (formative)	Train is efficient
SES	Respondent's socio-economic status (formative)	Higher Education
ULM	Urban home place, low motorization (formative)	Urban
Self-Utility	Perceived self-utility of car versus public transport (formative)	Car is most useful
Social Valuation	Social valuation of PT versus car (formative)	PT is favoured

SEM and Formative Models (1)



Measurements → Latent variables → response → fixed effects and error terms GSEM used for multinomial response – Bernoulli (probability: car, bus, train)
Yields a bipolar factor on a continuous scale (« predicted factor scores ») usually standardized to ease interpretation

Final SEM – the indirect effects (2)

Commuter satisfaction	Standardized coefficient	Sig.
Train Comfort Attitude	0.07	***
Socio-economic status	-0.04	***
Urban-low motorization	0.01	***
Train Cost-Efficiency Assessment		
Pro-Environment Attitude	**0.10**	***
Perceived utility of car		
Train Cost-efficiency Assessment	-0.04	***
Train Comfort Attitude	**-0.35**	***
Pro-Car Attitude	-0.22	***
Socio-economic status	**-0.09**	***
Urban-low motorization	-0.03	***
Pro-Environment Attitude	**-0.45**	***
Driving car while commuting		
Train Cost-efficiency Assessment	-0.08	***
Commuter satisfaction	-0.08	***
Train Comfort Attitude	**-0.18**	***
Pro-Car Attitude	0.39	***
Socio-economic status	**-0.08**	***
Urban-low motorization	-0.05	***
Pro-Environment Attitude	**-0.08**	***

Significance:
* p<0.05; ** p<0.01;
*** p<0.001

Based on correlation paths, indirect effects reveal that pro-environmental attitude had influence on utility and mode choice, but without direct link; as well *socio-economic status* and *perceived comfort of train* have a moderation effect on utility and car use (direct + indirect)

Final SEM – The total effects (4)

Correlations among latent variables	TCA	TEA	PCA	PEA	TCE	SES	ULM
Train Comfort Attitude (TCA)	1						
Train Environment Attitude (TEA)	0.821*	1					
Pro-Car Attitude (PCA)	-0.711*	-0.672*	1				
Pro-Environment Attitude (PEA)	0.502*	0.444*	-0.531*	1			
Train Cost-Efficiency (TCE)	0.151*	0.204*	-0.102*		1		
Socio-economic Status (SES)			-0.250*	0.142*		1	
Urban-lower motorization (ULM)	0.071*		-0.104*		0.096*	0.063	1
Perceived utility of public transit	0.622*	0.632*	-0.803*	0.439*	0.439*	0.411*	0.328*

* $p<0.01$ with Bonferroni correction; correlations with $p<0.05$ are not printed

Correlations assess the total relationships between attitudes and perceived self-utility, but do not distinguish directs and indirect effects, which is prerequisite to ensure efficiency of public policies and avoid unwanted side effects (we need to identify appropriate levers and propagation paths of secondary impacts on the response)