Partial Least Squares Path Modeling: Introduction and Application

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1 INTRODUCTION

Nowadays Partial Least Squares (PLS) path modeling is mostly applied in the context of marketing studies like customer satisfaction analysis. It can be used in order to investigate the effects of changes in the model specification or in the data of life datasets, for example. The seminar covered the following contents.

- Structural equation modeling with PLS
- Essential characteristics of PLS Path Modeling
- Formative vs. reflective measurement
- Software Tutorial: SmartPLS software environment and data entry
- PLS algorithm essentials
- Convergence of the PLS algorithm
- Creating valid PLS path models
- Evaluation of the Measurement Model: Reliability and Validity Assessment
- Evaluation of PLS path modeling results for the structural model
- Blindfolding
- Bootstrapping
- Software Tutorial: Interpreting SmartPLS output and significance testing
- Analyzing mediating effects
- 2nd-order constructs

- Analyzing moderating effects
- Multi-group Analysis
- Measurement model invariance

2 PLS PATH MODELING

2.1 Why to use PLS path modeling?

PLS path modeling can be used when working with complex problems or small samples. According to Jakobowicz (2006) "[i]ts soft assumptions gives it serious advantages over covariance structure analysis", meaning that "[s]oft modeling techniques are opposed to hard modeling techniques because of the soft distributional assumption". PLS path modeling should be used in complex models containing many latent variables. (Henseler 2012.)

2.2 Where can PLS path modeling articles be found?

- Journal of Marketing
- Journal of Marketing research
- Marketing Science
- Journal of Consumer research
- Journal of the Academy of Marketing Science

(Henseler 2012.)

2.3 Formative versus Reflective Measurement Models

Two types of measurement models have been introduced. The first introduced measurement model is the formative measurement model. A formative measurement model has the following properties:

- "direction of causality is from construct to measure"
- there is no expectation of indicators to be correlated
- "dropping an indicator from the measurement model may alter the meaning of the construct"
- mostly applied for success factor research

In comparison to the formative measurement model, a reflective measurement model can be recognized when it contains the following properties.

- it is expected that measurement errors are zero

- the variance of the latent variable is one
(Henseler 2012.)

2.4 What needs to be considered when specifying PLS path model?

First of all the model designer should decide which latent variables should be included in the PLS path model. Then the interrelation of latent variables should be checked in order to find out if there is a linear relation or not, if there is an interaction, a mediation or if these variables are not related to each other. (Henseler 2012.)

2.5 The SmartPLS Software

SmartPLS was developed by Christian Ringle and his team at the University of Hamburg in Germany. It is a software that can be used for PLS path modeling and it is currently free for individual use. SmartPLS is used by 16000 users worldwide and has the capability to determine the "relationships between independent and dependent latent variables as linear composites, much like multiple regression multivariate techniques". In terms of Structural Equation Modeling (SEM) Smart PLS has the capability to determine the direct as well as the indirect path influences among all latent variables belonging to a nomological network. Furthermore, the SmartPLS software is because of its Graphical User Interface (GUI) very user friendly. There are good tutorials available in the world wide web as well as videos in which they describe stepwise what needs to be done in order create a PLS path model. (PLS-SEM)

2.6 SmartPLS Restrictions

The SmartPLS Software has some restrictions. One restriction is that the path model must be recursive and thus it may not contain any causal loop. Furthermore, every latent variable must have at least one assigned indicator. Another restriction is that each indicator may only be assigned once per latent variable. (Henseler 2012.)

2.7 Evaluating Formative and Reflective Measurement Models

Formative Measurement Models can be evaluated with two criteria. One criteria is the significance of weights meaning that estimates for the model should be at significance levels. This can be achieved by applying the Bootstrap procedure. The second criterion is multicollinearity where "manifest variables in a formative block

must be tested for multicollinearity".

Reflective Measurement Models can be evaluated according to the following criteria. One criterion is called factor loadings which should be higher than 0.7. Another criterion is the so called composite reliability. According to Henseler (2012) the composite reliability as a measure of internal consistency should be higher than 0.6. In the Average Variance Extracted (AVE) criterion the average variance should be higher than 0.5. An essential role plays also the discriminant validity, where "[t]he extracted average variances of the latent variables should be greater than the square of the correlations among the latent variables, indicating that more variance is shared between the latent variable component and its block of indicators than with another block representing a different block of indicators". (Henseler 2012.)

3 CONCLUSION

In this seminar we have learned how to create and build formative and reflective measurement models in PLS path modeling with the use of SmartPLS software. Furthermore the algorithm of PLS was explained. Another interesting part was the presentation of "Error terms and their effects on measurement", "Internal consistency reliability: Cronbach's Alpha", "Indicator reliability", "convergence validity: average variance extracted", "The parametric approaches", etc. It was a very good and intersting course that gave a lot of PLS path modeling information to the participants.

4 BIBLIOGRAPHY

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