

# Estimating a PLS-SEM

## Model Estimation in SEMinR

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2021-04-27 (updated: 2021-07-12)

# PLS model estimation in SEMinR

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3. The SEMinR model object
4. Troubleshooting

# Before estimation

What you need to estimate a model:

- Data
- Measurement model
- Structural model

# Before estimation - example

```
# load seminr library
library(seminr)
# define measurement model mm
mm <- constructs(
  # define mode A composite construct: long form
  composite(construct_name = "Reputation",
            item_names = multi_items("IMAG", 1:5),
            weights = correlation_weights),
  # define mode A composite construct: shorter form
  composite("Satisfaction",
            multi_items("CUSA", 1:3),
            mode_A),
  # define mode A composite construct: even shorter form
  composite("Loyalty",
            multi_items("CUSL", 1:3))
)
```

# Before estimation - example

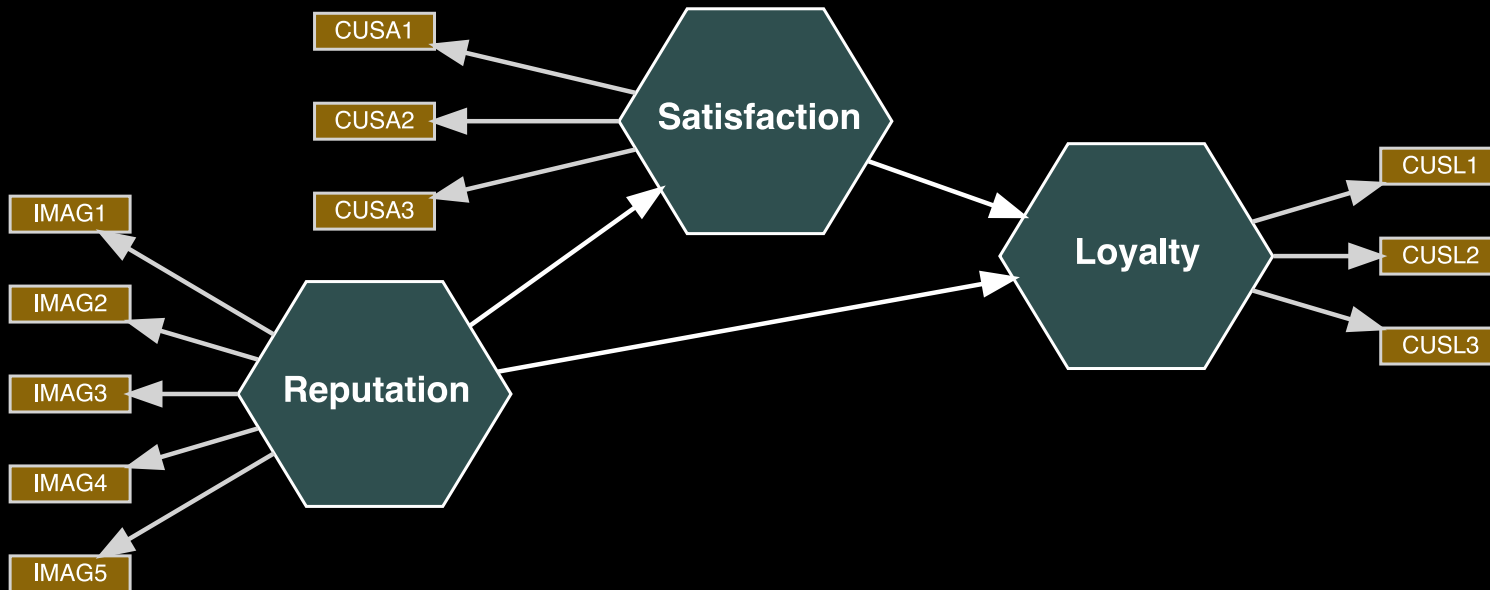
```
# define structural model
sm <- relationships(
  paths(
    from = "Reputation",
    to = c("Satisfaction", "Loyalty")
  ),
  paths(
    from = "Satisfaction",
    to = "Loyalty"
  )
)
```

# Before estimation - example

```
# specify model without estimating it
specify_model(measurement_model = mm,
              structural_model = sm) %>%
  # plot model
  plot()
```

# Before estimation - example

```
# specify model without estimating it
specify_model(measurement_model = mm,
              structural_model = sm) %>%
  # plot model
  plot()
```



# Estimating a model

```
# estimate a pls model
model <- estimate_pls(
  data = mobi,
  measurement_model = mm,
  structural_model = sm,
  model = NULL,
  inner_weights = path_weighting,
  missing = mean_replacement,
  missing_value = NA
)
```



# Estimating a model - the fundamentals

```
model <- estimate_pls(  
  data = mobi,          # data as data frame or matrix  
  measurement_model = mm, # measurement model  
  structural_model = sm,  # structural model  
  model = NULL,  
  inner_weights = path_weighting,  
  missing = mean_replacement,  
  missing_value = NA  
)
```

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model <- estimate_pls(  
  data = mobi,           # data as data frame or matrix  
  measurement_model = mm, # measurement model  
  structural_model = sm,  # structural model  
  model = NULL,  
  inner_weights = path_weighting,  
  missing = mean_replacement,  
  missing_value = NA  
)
```

Equivalent code:

```
model <- estimate_pls(mobi, mm, sm)
```

# Estimating a model - *model*

```
model <- estimate_pls(  
  data = mobi,  
  measurement_model = mm,  
  structural_model = sm,  
  # optional: model object generated by specify_model()  
  # only necessary if mm and sm are not provided  
  model = NULL,  
  inner_weights = path_weighting,  
  missing = mean_replacement,  
  missing_value = NA  
)
```

# Estimating a model - *model*

```
model <- estimate_pls(  
  data = mobi,  
  measurement_model = mm,  
  structural_model = sm,  
  # optional: model object generated by specify_model()  
  # only necessary if mm and sm are not provided  
  model = NULL,  
  inner_weights = path_weighting,  
  missing = mean_replacement,  
  missing_value = NA  
)
```

```
specified_model <- specify_model(  
  measurement_model = mm,  
  structural_model = sm  
)
```

# Estimating a model - *inner\_weights*

```
model <- estimate_pls(  
  data = mobi,  
  measurement_model = mm,  
  structural_model = sm,  
  model = NULL,  
  # optional: how paths are estimated  
  # defaults to path weighting  
  inner_weights = path_weighting,  
  missing = mean_replacement,  
  missing_value = NA  
)
```

# Estimating a model - *inner\_weights*

```
model <- estimate_pls(  
  data = mobi,  
  measurement_model = mm,  
  structural_model = sm,  
  model = NULL,  
  # optional: how paths are estimated  
  # defaults to path weighting  
  inner_weights = path_weighting,  
  missing = mean_replacement,  
  missing_value = NA  
)
```

Further reading: Tenenhaus et al. (2005). PLS path modeling.

# Estimating a model - *missing*

```
model <- estimate_pls(  
  data = mobi,  
  measurement_model = mm,  
  structural_model = sm,  
  model = NULL,  
  inner_weights = path_weighting,  
  # optional: how missing values are treated  
  # defaults to mean replacement  
  missing = mean_replacement,  
  missing_value = NA  
)
```

# Estimating a model - *missing*

Alternatively: Disregard observations with missing values

```
model <- estimate_pls(  
  data = mobi,  
  measurement_model = mm,  
  structural_model = sm,  
  model = NULL,  
  inner_weights = path_weighting,  
  # do not use observations with missing values  
  missing = na.omit,  
  missing_value = NA  
)
```



# Estimating a model

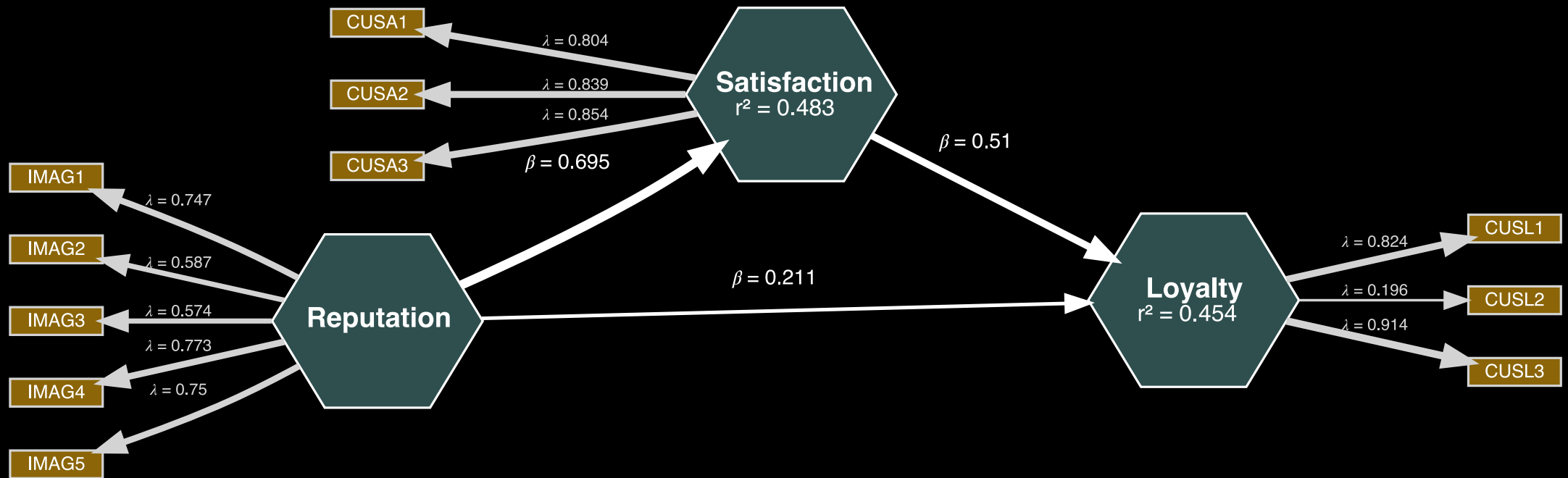
```
model <- estimate_pls(  
  data = mobi,  
  measurement_model = mm,  
  structural_model = sm  
)
```

```
## Generating the seminr model
```

```
## All 250 observations are valid.
```

# The SEMinR model object - plot

```
plot(model)
```



# The SEMinR model object - subobjects

```
> model$
```

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```
> model$
```

Means of all indicators:

```
model$meanData
```

```
##  IMAG1  IMAG2  IMAG3  IMAG4  IMAG5  CUSA1  CUSA2  CUSA3  CUSL1  CUSL2  CUSL3  
##  7.640  7.780  6.744  7.588  7.932  7.988  7.128  7.316  7.452  4.988  7.668
```

# The SEMinR model object - subobjects

```
> model$
```

Means of all indicators:

```
model$meanData
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```
## IMAG1 IMAG2 IMAG3 IMAG4 IMAG5 CUSA1 CUSA2 CUSA3 CUSL1 CUSL2 CUSL3  
## 7.640 7.780 6.744 7.588 7.932 7.988 7.128 7.316 7.452 4.988 7.668
```

Number of iterations until convergence:

```
model$iterations
```

```
## [1] 6
```

And many more!

# The SEMinR model object - summary

```
summary(model)
```

```
##
## Results from package seminr (2.0.3)
##
## Path Coefficients:
##           Satisfaction Loyalty
## R^2           0.483    0.454
## AdjR^2        0.481    0.449
## Reputation    0.695    0.211
## Satisfaction      .    0.510
##
## Reliability:
##           alpha  rhoC  AVE  rhoA
## Reputation  0.723 0.819 0.478 0.745
## Satisfaction 0.779 0.871 0.693 0.786
## Loyalty     0.472 0.721 0.518 0.743
```

# The SEMinR model object - summary subobjects

```
summarymodel <- summary(model)
```

# The SEMinR model object - summary subobjects

```
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```

Informations on discriminant validity:

```
summarymodel$validity$vif_items
```

```
## Reputation :  
## IMAG1 IMAG2 IMAG3 IMAG4 IMAG5  
## 1.468 1.225 1.259 1.510 1.403  
##  
## Satisfaction :  
## CUSA1 CUSA2 CUSA3  
## 1.505 1.762 1.644  
##
```



# Troubleshooting - 'x' must be numeric

```
# transform variable to character  
dt2 <- mobi %>%  
  mutate(IMAG1 = IMAG1 %>%  
    as.character())
```

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    as.character())
```

```
# this creates an error  
estimate_pls(dt2, mm, sm)
```

```
Generating the seminr model  
argument is not numeric or logical: returning NA  
All 250 observations are valid.  
Error in colMeans(x, na.rm = TRUE) : 'x' must be numeric
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```

Generating the seminr model  
argument is not numeric or logical: returning NA  
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```
# select variables that are not numeric  
dt2 %>% select(!where(is.numeric))
```

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# transform variable to character  
dt2 <- mobi %>%  
  mutate(IMAG1 = IMAG1 %>%  
    as.character())
```

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# this creates an error  
estimate_pls(dt2, mm, sm)
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Generating the seminr model  
argument is not numeric or logical: returning NA  
All 250 observations are valid.  
Error in colMeans(x, na.rm = TRUE) : 'x' must be numeric

```
# select variables that are not numeric  
dt2 %>% select(!where(is.numeric))
```

# Troubleshooting - *undefined columns selected*

```
mm2 <- constructs(  
  composite("Reputation",  
    # what happens if I make a typo when choosing indicators?  
    multi_items("IMGA", 1:5)),  
  composite("Satisfaction",  
    multi_items("CUSA", 1:3)),  
  composite("Loyalty",  
    multi_items("CUSL", 1:3))  
)
```

# Troubleshooting - *undefined columns selected*

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mm2 <- constructs(  
  composite("Reputation",  
    # what happens if I make a typo when choosing indicators?  
    multi_items("IMGA", 1:5)),  
  composite("Satisfaction",  
    multi_items("CUSA", 1:3)),  
  composite("Loyalty",  
    multi_items("CUSL", 1:3))  
)
```

```
estimate_pls(dt, mm2, sm)
```

```
Error in `[.data.frame`(data, , mmMatrix[which(!grepl("\\*",  
mmMatrix[, : undefined columns selected
```

# Troubleshooting - *attempt to apply non-function*

```
sm2 <- relationships(  
  paths(  
    from = "Reputation",  
    to = c("Satisfaction", "Loyalty")  
  ),  
  paths(  
    from = "Satisfaction",  
    # what happens if I include a rogue construct?  
    to = c("Loyalty", "Quality")  
  )  
)
```

# Troubleshooting - *attempt to apply non-function*

```
sm2 <- relationships(  
  paths(  
    from = "Reputation",  
    to = c("Satisfaction", "Loyalty")  
  ),  
  paths(  
    from = "Satisfaction",  
    # what happens if I include a rogue construct?  
    to = c("Loyalty", "Quality")  
  )  
)
```

```
estimate_pls(dt, mm, sm2)
```



# Summary

- Model estimation with `estimate_pls()`
- Model object and model summary object
- Common errors

# Sources for this video

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). A primer on partial least squares structural equation modeling (PLS-SEM) (Second edition). Sage.

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[https://doi.org/10.1108/S1474-7979\(2009\)0000020014](https://doi.org/10.1108/S1474-7979(2009)0000020014)

Ray, S. & Danks, N. (2020). SEMinR Vignette. <https://cran.r-project.org/web/packages/seminr/vignettes/SEMinR.html>

Tenenhaus, M., Vinzi, V. E., Chatelin, Y.-M., & Lauro, C. (2005). PLS path modeling. *Computational Statistics & Data Analysis*, 48(1), 159–205.  
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