Bootstrapping a PLS-SEM

Bootstrapping in SEMinR

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PLS model estimation in SEMinR

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2. How bootstrapping works
3. Bootstrapping a model
4. The SEMinR bootstrapped model object

Why we bootstrap

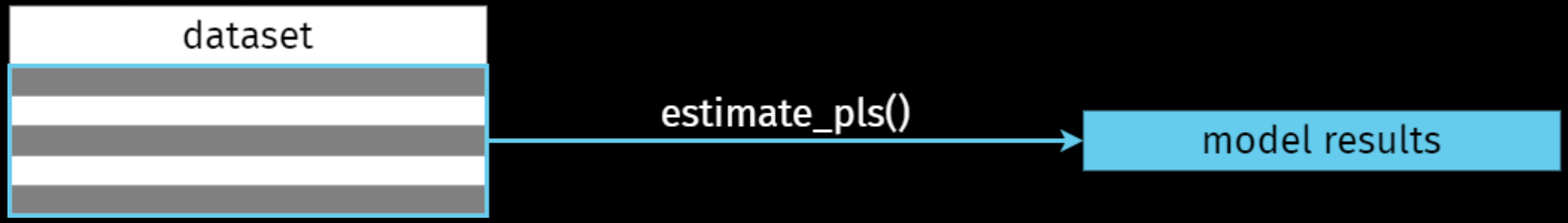
Bootstrapping gives you significance information for

- path coefficients
- weights
- loadings
- HTMT ratios

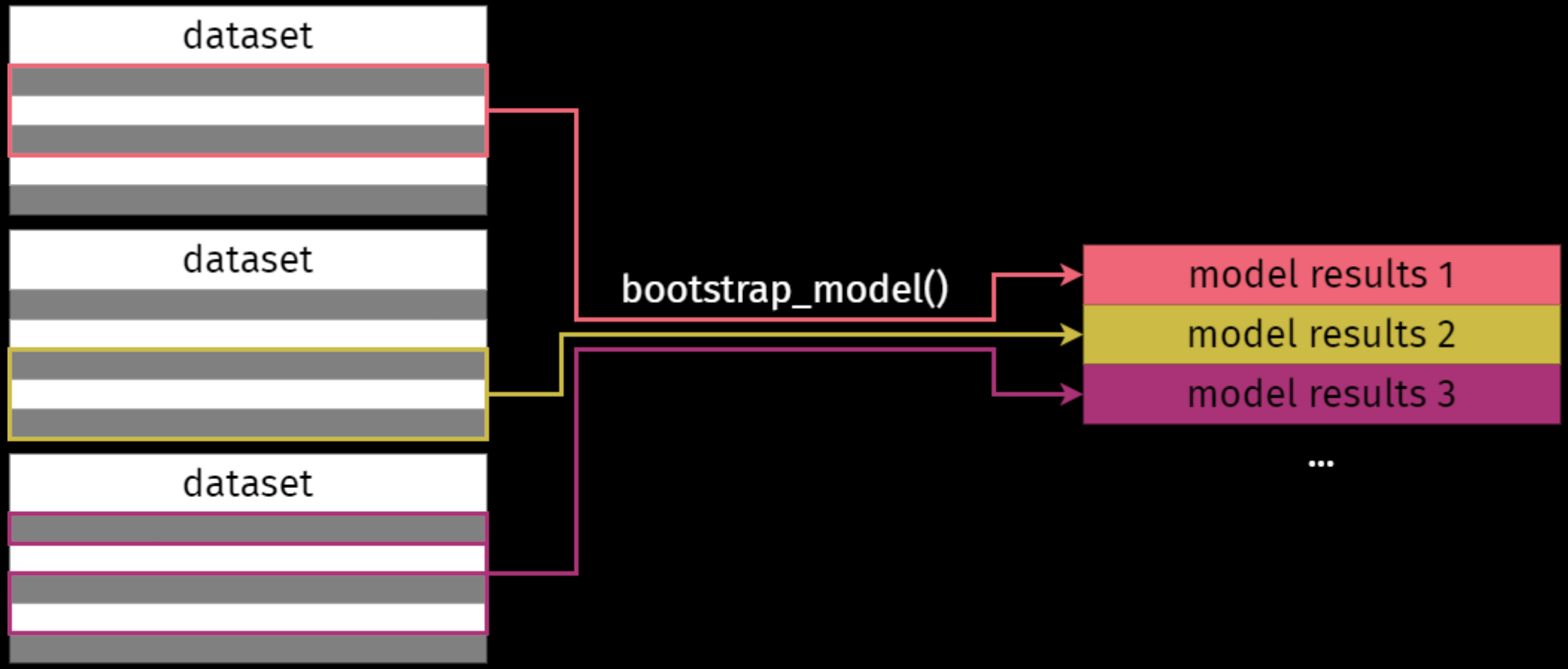
... given your data

How bootstrapping works

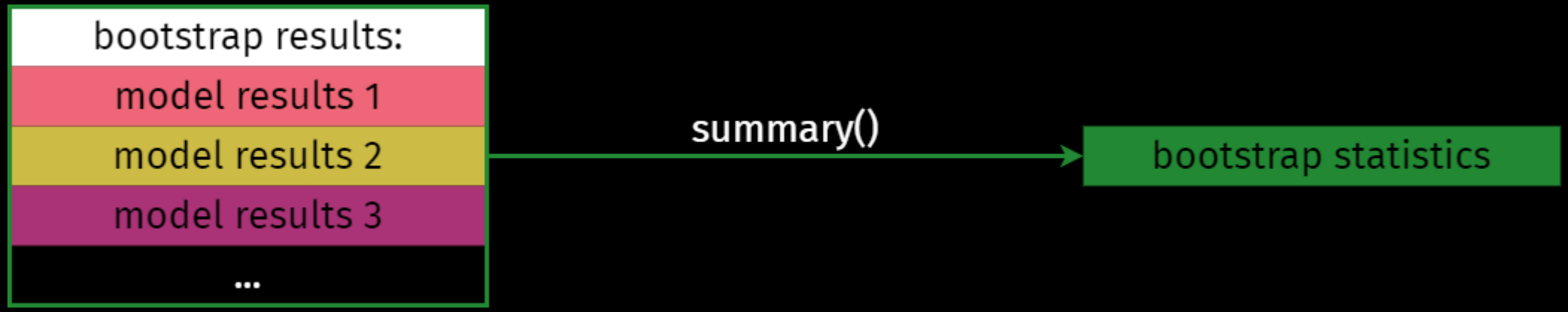
Regular model estimation process:



How bootstrapping works



How bootstrapping works



Statistics include mean, standard deviation and confidence intervals on the basis of the different model results.

Bootstrapping a model - preparation

```
# load seminr library
library(seminr)
# quickly estimate model
model <- estimate_pls(
  data = mobi,
  measurement_model = constructs(
  composite("Reputation", multi_items("IMAG", 1:5)),
  composite("Satisfaction", multi_items("CUSA", 1:3)),
  composite("Loyalty", multi_items("CUSL", 1:3))),
  structural_model = relationships(
  paths(from = "Reputation", to = c("Satisfaction", "Loyalty")),
  paths(from = "Satisfaction", to = "Loyalty"))
)
```

```
## Generating the seminr model

## All 250 observations are valid.
```

Bootstrapping a model - the fundamentals

```
# bootstrap the model
bootstrapmodel <- bootstrap_model(
  seminr_model = model,   # a pls model
  nboot = 500,            # the number of bootstrap iterations
  cores = NULL,
  seed = NULL
  )
```

Bootstrapping a model - *cores* and *seed*

```
# bootstrap the model
bootstrapmodel <- bootstrap_model(
  seminr_model = model,
  nboot = 500,
  cores = NULL,           # the maximum number of cores to use
  seed = NULL             # the random seed
  )
```

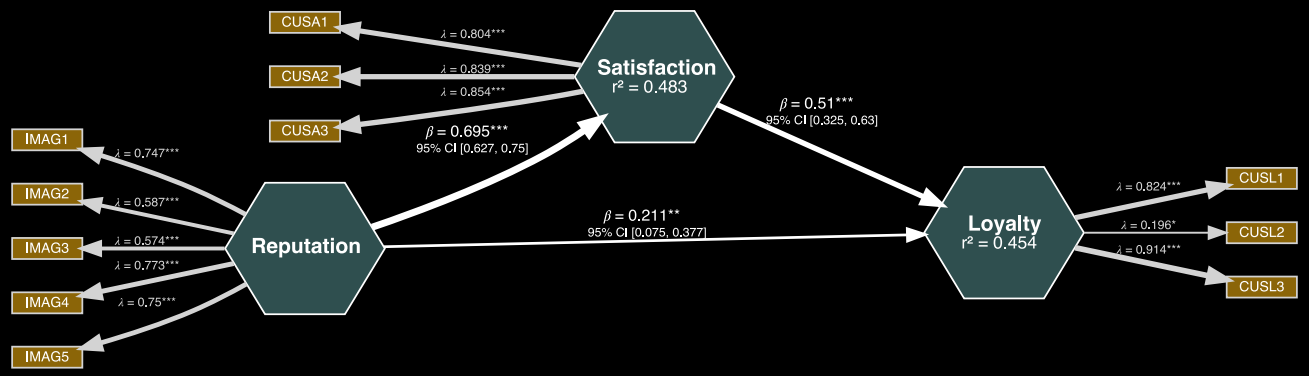
Bootstrapping a model

```
# bootstrap the model
bootstrapmodel <- bootstrap_model(
  seminr_model = model,
  nboot = 100
  )
```

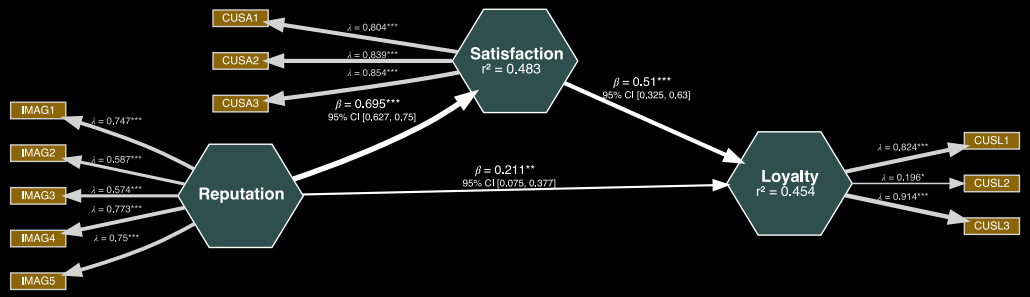
```
## Bootstrapping model using seminr...

## SEMinR Model successfully bootstrapped
```

The SEMinR bootstrap model object - plot

```
plot(bootstrapmodel)
```



The SEMinR bootstrap model object - plot



$^{***}p < .001, \, ^{**}p < .01, \, ^{*}p < .05$

95% CI[lower bound, upper bound]

The SEMinR bootstrap model object - subobjects

```
> bootstrapmodel$
```

```
bootstrapmodel$boot_paths
```

```
## , , 1
##
##              Reputation Satisfaction   Loyalty
## Reputation            0    0.6975628 0.1547664
## Satisfaction          0    0.0000000 0.5838384
## Loyalty               0    0.0000000 0.0000000
##
## , , 2
##
##              Reputation Satisfaction   Loyalty
## Reputation            0    0.6904222 0.2015742
## Satisfaction          0    0.0000000 0.5927379
## Loyalty               0    0.0000000 0.0000000
##
```

The SEMinR bootstrap model object - summary

```
# print summary of the bootstrapped model
summary(bootstrapmodel)
```

```
##
## Results from Bootstrap resamples:  100
##
## Bootstrapped Structural Paths:
##                            Original Est. Bootstrap Mean Bootstrap SD T Stat. 2.5% CI 97.5% CI
## Reputation  ->  Satisfaction         0.695          0.697        0.033  20.926   0.627    0.750
## Reputation  ->  Loyalty              0.211          0.218        0.076   2.763   0.075    0.377
## Satisfaction  ->  Loyalty            0.510          0.501        0.086   5.904   0.325    0.630
##
## Bootstrapped Weights:
##                          Original Est. Bootstrap Mean Bootstrap SD T Stat. 2.5% CI 97.5% CI
## IMAG1  ->  Reputation            0.305          0.306        0.024  12.726   0.262    0.348
## IMAG2  ->  Reputation            0.243          0.247        0.032   7.697   0.190    0.312
## IMAG3  ->  Reputation            0.211          0.206        0.034   6.162   0.148    0.264
## IMAG4  ->  Reputation            0.335          0.331        0.026  13.061   0.280    0.378
## IMAG5  ->  Reputation            0.333          0.335        0.030  11.238   0.285    0.397
```

The SEMinR model object - summary subobjects

```
# save summary of the bootstrapped model
summarybootmodel <- summary(bootstrapmodel)
```

```
# number of bootstrap iterations
summarybootmodel$nboot
```

```
## [1] 100
```

The SEMinR model object - summary subobjects

```
# bootstrapped paths
summarybootmodel$bootstrapped_paths
```

```
##                              Original Est. Bootstrap Mean Bootstrap SD T Stat. 2.5% CI 97.5% CI
## Reputation  ->  Satisfaction         0.695          0.697        0.033  20.926   0.627    0.750
## Reputation  ->  Loyalty              0.211          0.218        0.076   2.763   0.075    0.377
## Satisfaction  ->  Loyalty            0.510          0.501        0.086   5.904   0.325    0.630
```

The SEMinR model object - summary subobjects

```
# bootstrapped weights
summarybootmodel$bootstrapped_weights
# bootstrapped loadings
summarybootmodel$bootstrapped_loadings
# bootstrapped HTMT
summarybootmodel$bootstrapped_HTMT
```

```
# bootstrapped total paths - includes mediated influence
summarybootmodel$bootstrapped_total_paths
```

```
##                            Original Est. Bootstrap Mean Bootstrap SD T Stat. 2.5% CI 97.5% CI
## Reputation  ->  Satisfaction         0.695          0.697        0.033  20.926   0.627    0.750
## Reputation  ->  Loyalty              0.565          0.568        0.054  10.468   0.457    0.680
## Satisfaction  ->  Loyalty            0.510          0.501        0.086   5.904   0.325    0.630
```

Summary

- Why we bootstrap
- How bootstrapping works
- Model bootstrapping with bootstrap_model()
- Bootstrapped model object and bootstrapped model summary object

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.

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