

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

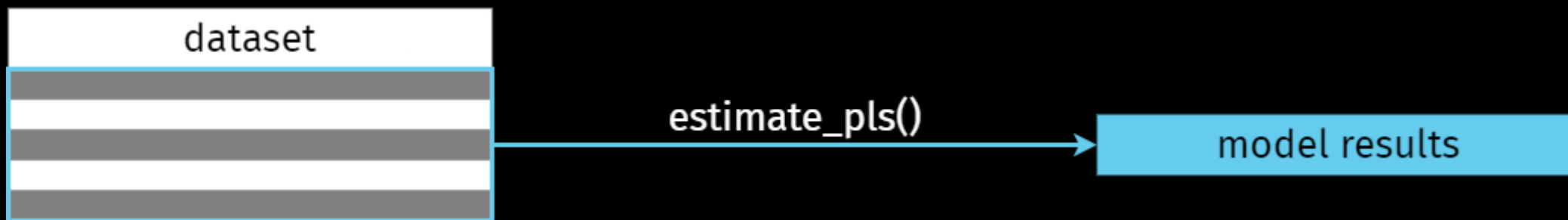
Bootstrapping gives you significance information for

- path coefficients
- weights
- loadings
- HTMT ratios

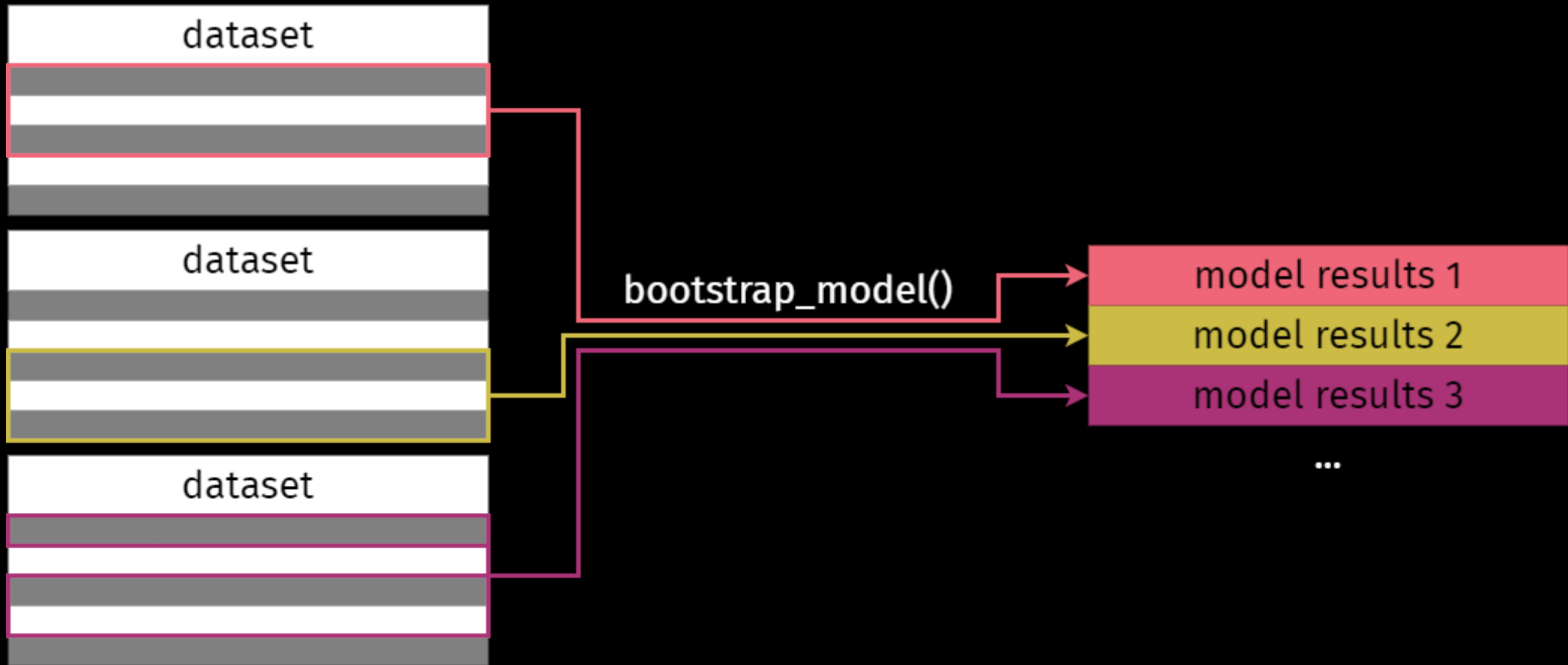
... given your data

How bootstrapping works

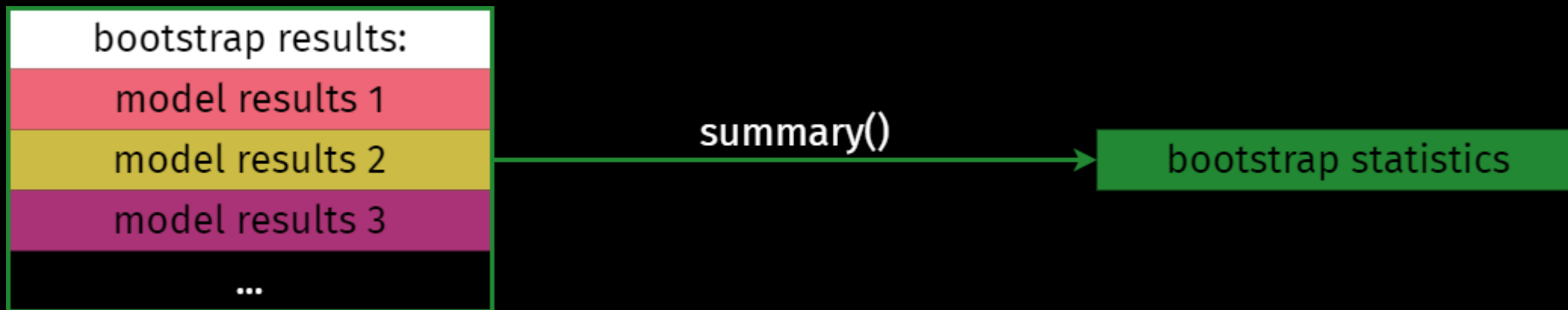
Regular model estimation process:



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

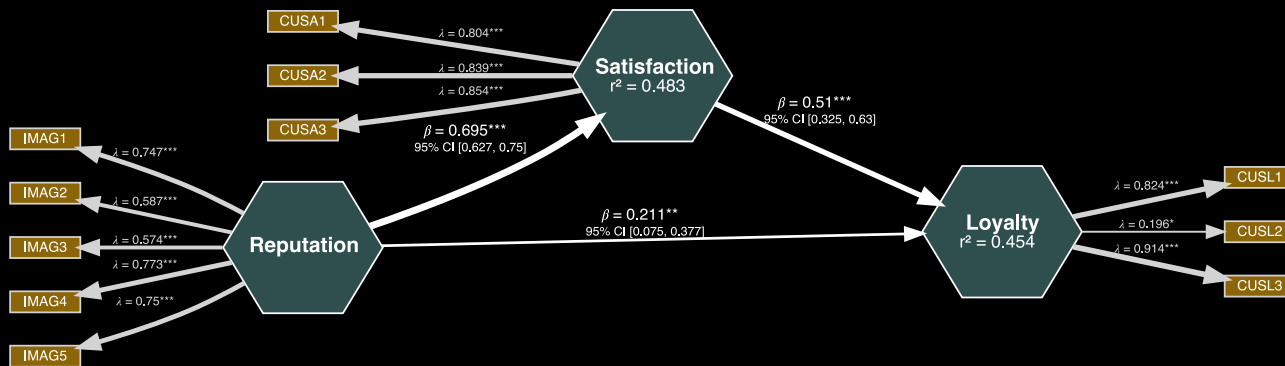
```
# bootstrap the model  
bootstrapmodel <- bootstrap_model(  
  seminr_model = model,  
  nboot = 100  
)
```

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

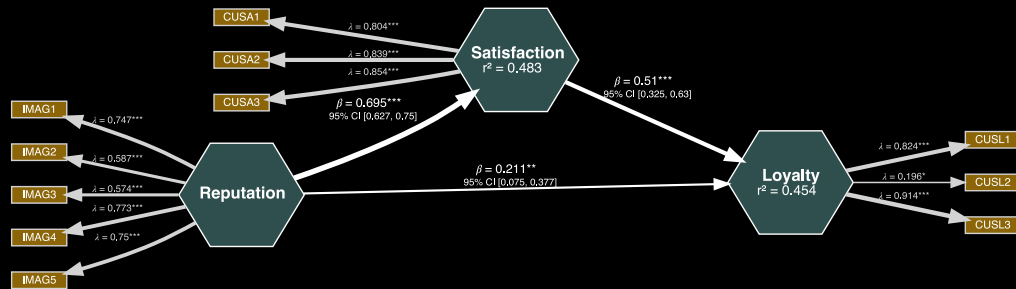
```
## SEMinR Model successfully bootstrapped
```

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
----	------------	--------------	---------

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.  
## Reputation -> Satisfaction      0.695      0.697      0.033    20.926  
## Reputation -> Loyalty           0.211      0.218      0.076     2.763  
## Satisfaction -> Loyalty         0.510      0.501      0.086     5.904  
##  
## Bootstrapped Weights:  
##  
##           Original Est. Bootstrap Mean Bootstrap SD T Stat. 2.5%  
## IMAG1 -> Reputation             0.305      0.306      0.024    12.72614 / 10 0.2
```

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.
##	Reputation -> Satisfaction	0.695	0.697	0.033	20.926
##	Reputation -> Loyalty	0.211	0.218	0.076	2.763
##	Satisfaction -> Loyalty	0.510	0.501	0.086	5.904

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.
## Reputation -> Satisfaction		0.695	0.697	0.033	20.926
## Reputation -> Loyalty		0.565	0.568	0.054	10.468
## Satisfaction -> Loyalty		0.510	0.501	0.086	5.904

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>