

# Bootstrapping a PLS-SEM

## Bootstrapping in SEMinR

Lilian Kojan

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# PLS model estimation in SEMinR

1. Why we bootstrap
2. How bootstrapping works
3. Bootstrapping a model
4. The SEMinR bootstrapped model object

# Why we bootstrap

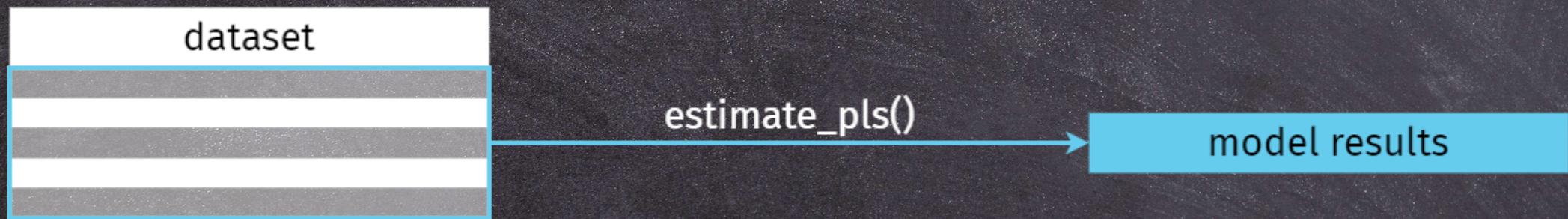
Bootstrapping gives you significance information for

- path coefficients
- weights
- loadings
- HTMT ratios

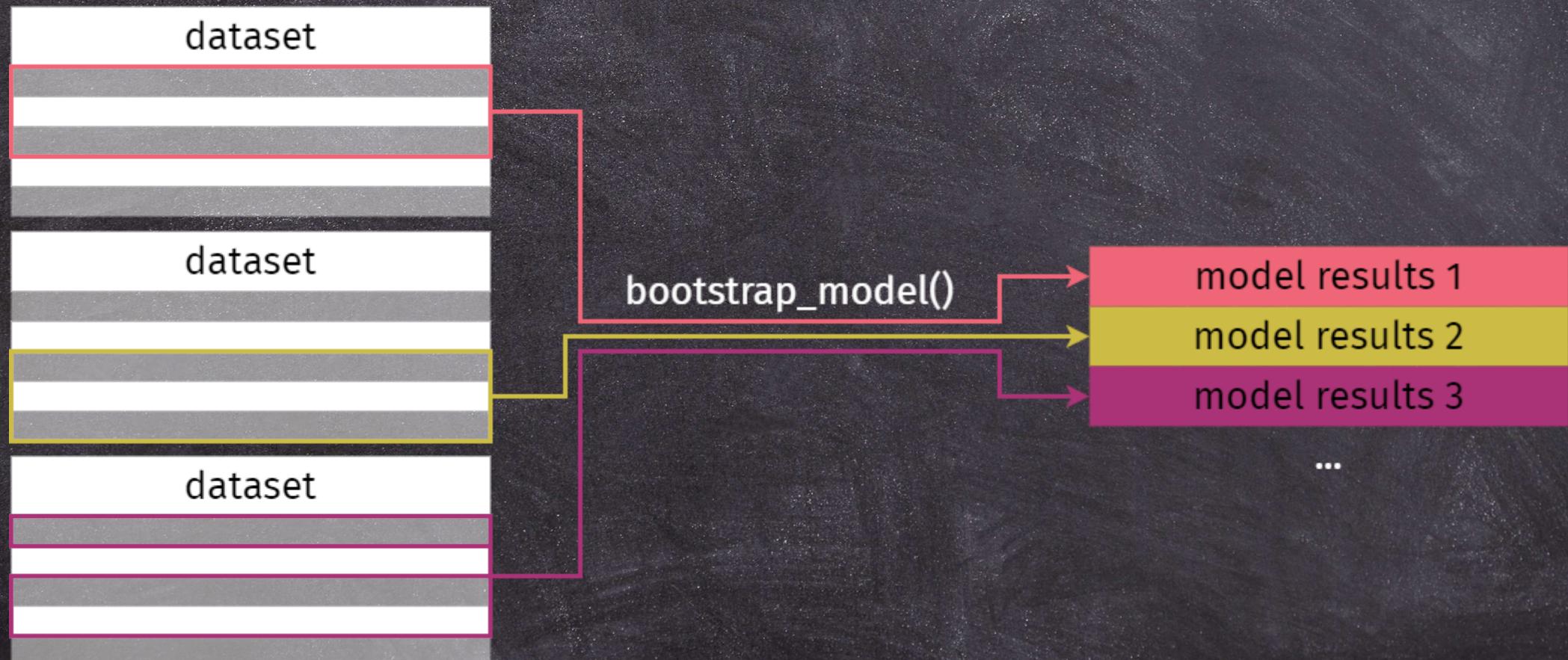
**... given your data**

# How bootstrapping works

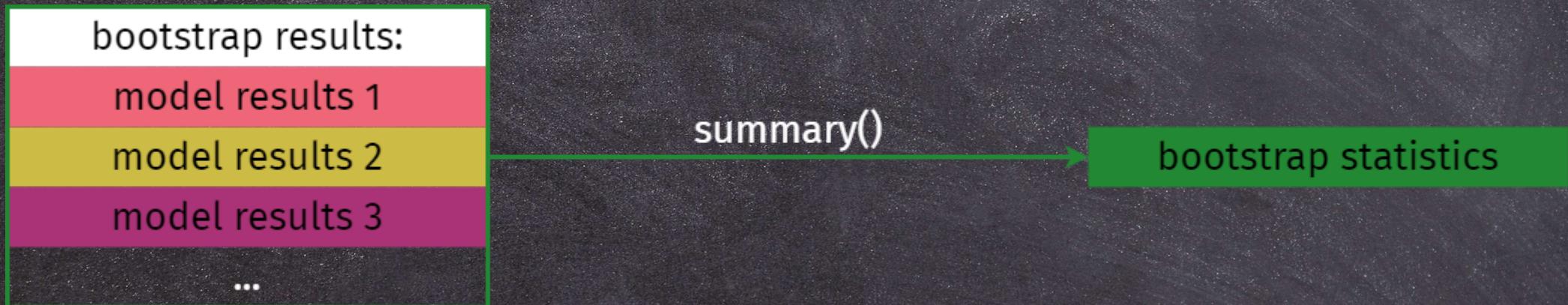
Regular model estimation process:



# 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
)
```

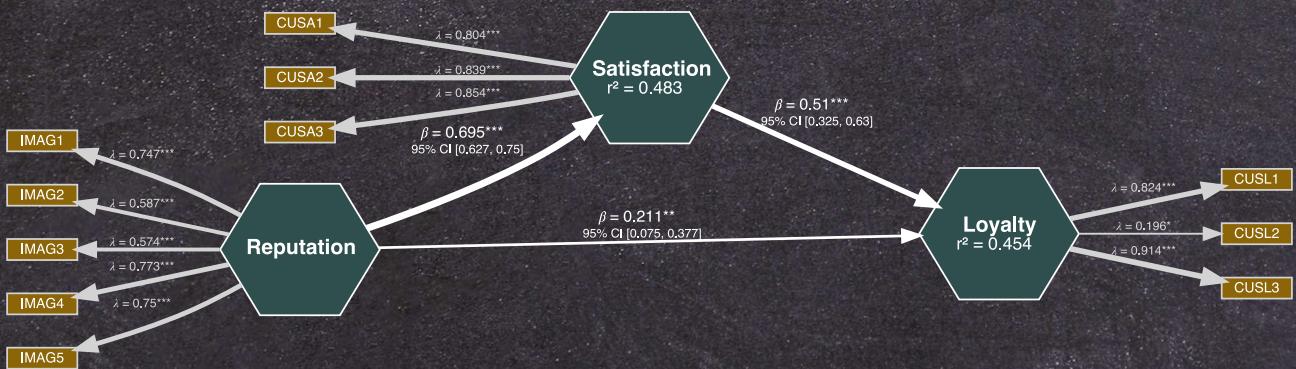
# Bootstrapping a model

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

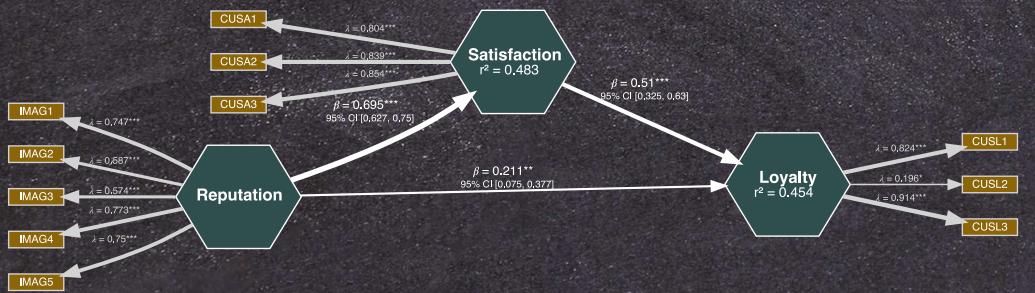
## Bootstrapping model using seminr...
## SEMinR Model successfully bootstrapped
```

# 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 / 19 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	57.904

# 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>