

# Testing – 6.3 $t$ -tests

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*Bootstrap*

The calculation of the  $t$  statistics is described in Week 3. It relies on approximations of the variance-covariance matrix of the estimates: the Cramer-Rao bound, and the robust/sandwich estimator. These approximations are derived from theoretical developments.

Alternatively, the variance covariance matrix can be approximated empirically using simulation. The technique, called *bootstrapping*, is described by Algorithm 1.

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**Algorithm 1** Approximate the variance-covariance matrix by bootstrapping

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- 1: Consider a sample of  $N$  observations.
  - 2: **for**  $r = 1, \dots, R$  **do**
  - 3:     Draw  $N$  observations from the sample with replacement.
  - 4:     Calculate the maximum likelihood estimates  $\hat{\beta}_r$  using the drawn sample.
  - 5: **end for**
  - 6: Calculate the empirical variance-covariance matrix of the vectors  $\hat{\beta}_r$ ,  $r = 1, \dots, R$ .
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