- Q: what's a conservative conclusion when H_0 is accepted? $X^*\beta^* \approx \hat{Y} \Leftarrow \hat{\sigma} \approx \sigma$ (cf.)
  ⇒ may not conclude $X\beta$ is the true model. We may say the true $E(Y) \approx X\beta$ on the observed data points
  ↳ e.g. over-fitting, many possible good models
- Q: can the procedure be modified to test overfitting?
  ↳ In principle, Yes, if it's possible to fit a model with $\hat{\sigma}^2 \ll$ true σ^2
  seems good. But, $Var(\hat{Y})$ large on future predictions (check LNp.7)
  over-fitting ⇒ high R^2, $Y \approx \hat{Y}$, RSS small
  In addition, (R^2, $Y \leftrightarrow \hat{Y}$)
  ① t-test, F-test for effect significance
  ② model selection
  ③ cross-validation
  ④ informal methods like residual analysis (LNp.8)
  - Note that fitting is not everything
    - ➢ it often possible to fit data perfectly by introducing more effects/predictors
    - ➢ for data without replication, you can fit a model with $R^2=1$ and zero $\hat{\sigma}^2$ ← $Y = \hat{Y}$
    - ➢ a very complex model can fit data perfectly (even exactly), but ... do not seperate 規 from 隨
      - may have no explanation (may learn nothing beyond the data itself)
      - prediction unstable → For $\hat{Y}$, overfitting: Var↑ bias↓, underfitting: Var↓ bias↑ (check graph in LNp.7)

Why is this important? Consider testing.

- Q: what is the source of variation in your data? ($X\beta$ and ε) ← Recall. R^2 ↑ 隨機 var / 規律 var
  what σ^2 is estimated (i.e., what is the source of variation in ε)? example:
  - replication generated from different units vs. repeated measures of same unit
  - repeatability vs. reproducibility in measurement system analysis
    - repeatability: variation under same condition
    - reproducibility: variation caused by different operators, ...

* two types of degrees of freedom:
(1) distinct x_i's → study 規律 & 隨機
(2) replicates → study 隨機

❖ **Reading**: Faraway (2005, 1st ed.), 6.3 ❖ **Futher reading**: D&S, 2.1