

# Predictive modelling in R

## *Review of Quantessentials*

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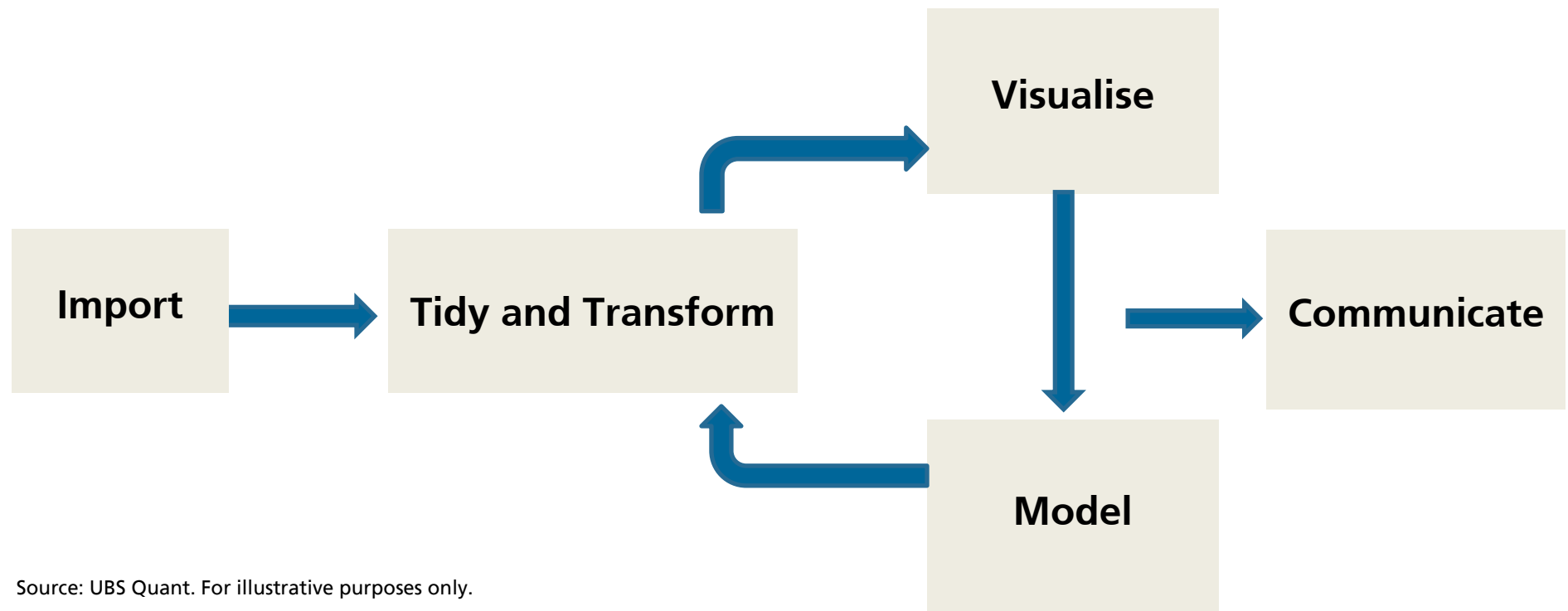
Section 1

# Quantessentials

# What is Quantessentials?

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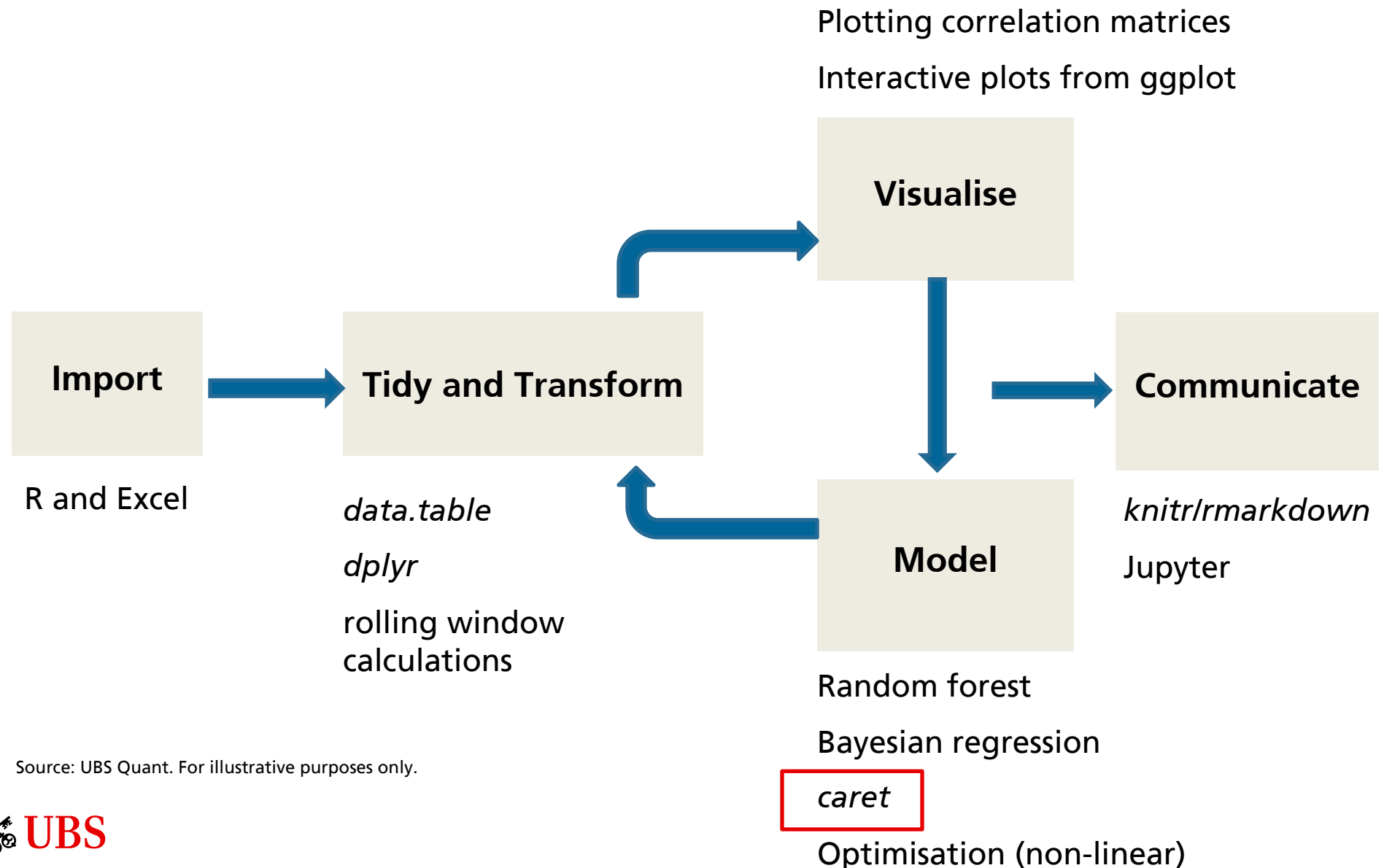
- Provide hints and tips on various aspects of Quant analysis
  - Focus on some of the technical aspects of our research
  - Explore real-world implementation issues
- Working with data (big or small) is an integral part of being a Quant
  - The main steps in data analysis:



Source: UBS Quant. For illustrative purposes only.

# R-advice

- Discuss various aspects of data analysis in R



Source: UBS Quant. For illustrative purposes only.

## Section 2

# Predictive modelling with *caret*

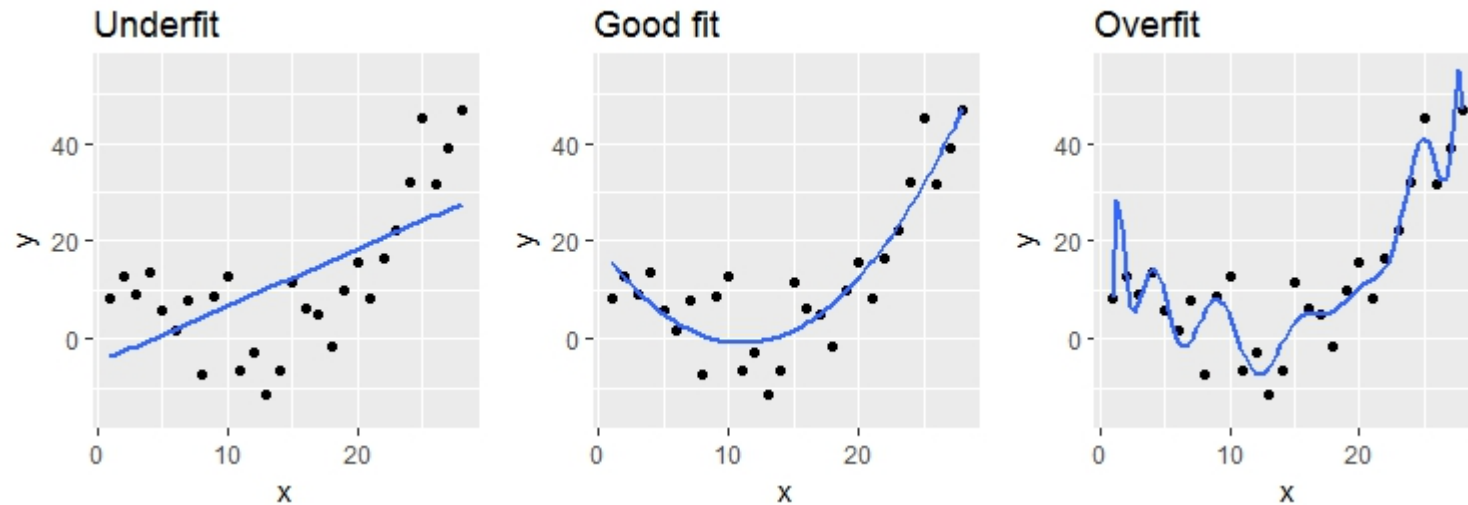
# What is *caret*?

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- It's an acronym: **C**lassification **A**nd **RE**gression **T**raining
- It's a meta-package:
  - Provides common interface to the most powerful learning algorithms in R
  - Does not implement ML algorithms
- Why is it useful?
  - **Model consistency:** 100+ packages for Machine Learning, each of which does things slightly differently (e.g. formulas vs design matrices interface)
  - Ensures different parts of building predictive models **work well together** (e.g. pre-processing vs training)
  - Provides tools to help with many of the practical problems in ML: **data pre-processing, overfitting, parameter tuning**
  - **Parallel processing** to speed up computations

# Overfitting

- The golden rule of Machine Learning: **Do not overfit your data!**



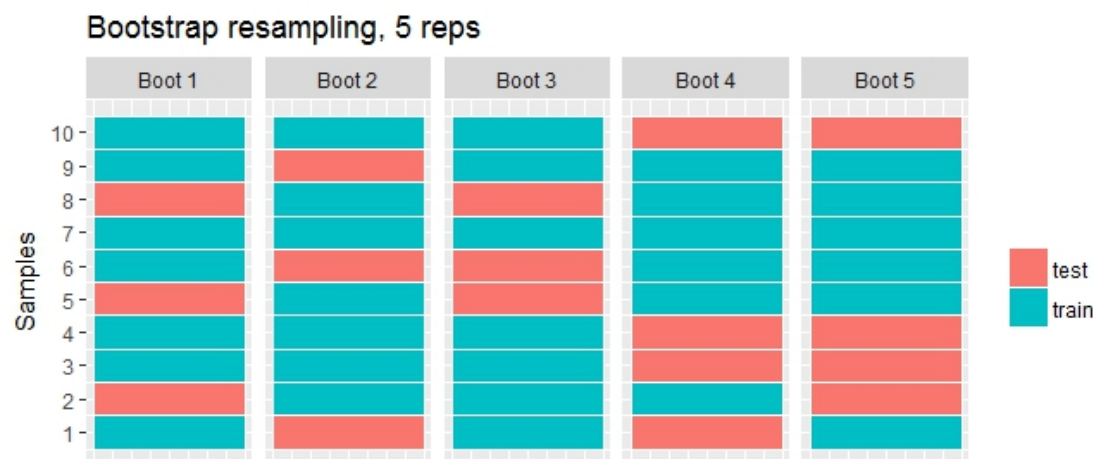
Source: UBS Quant. The linear model (left) is insufficient to describe the relationship in the data. The polynomial model (right) learns the noise in the data as opposed to the signal.

- How do we detect and avoid overfitting?
  - Use a test set
  - Use resampling to estimate parameters

# Resampling schemes

- Bootstrap resampling

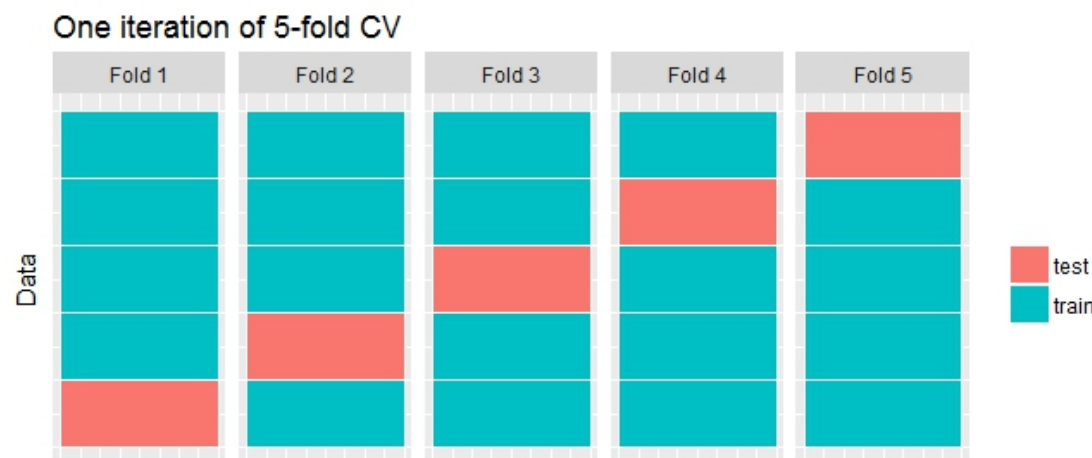
- Take a random sample with replacement
- Same size as original data, some samples selected more than once
- Use the samples that weren't selected to test



Source: UBS Quant. For illustrative purposes only.

- Repeated K-fold Cross Validation (CV)

- Split data into  $K$  groups (roughly the same size)
- Train on  $K - 1$  of the blocks and test on the final
- Can create multiple versions of the folds and take averages



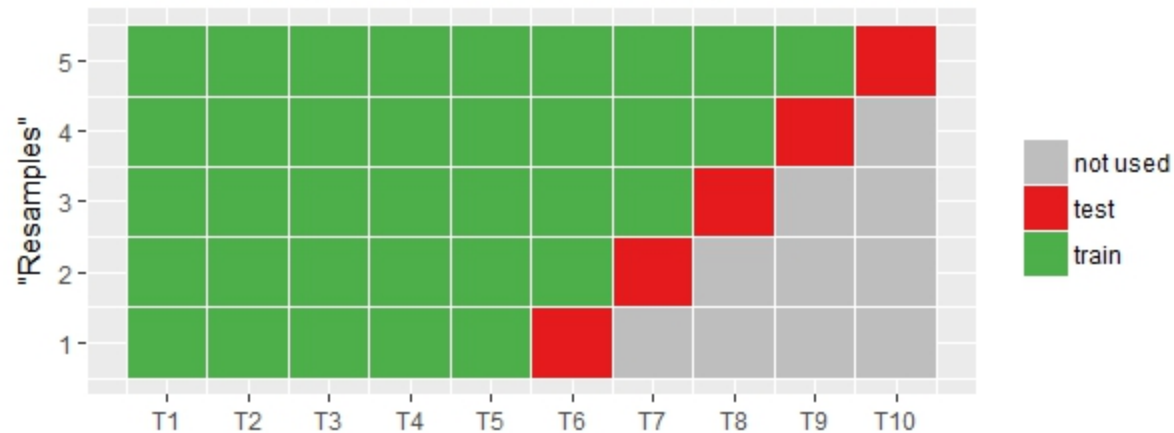
Source: UBS Quant. For illustrative purposes only.



# Time series resampling

- Need to keep the temporal structure of the data
- Neither bootstrapping nor CV can be used with time series data
- Time slice resampling:
  - Expanding window
  - Rolling (fixed) window

Time slice: expanding window, one step ahead forecast



Source: UBS Quant. For illustrative purposes only.

Time slice: fixed window, one step ahead forecast



Source: UBS Quant. For illustrative purposes only.

# Tuning of hyper-parameters

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- Unlike regular parameter, hyper-parameters cannot be inferred from the data
- Typically, there are no "smart defaults" (KNN, regularised regression)
- Use resampling to tune hyper-parameters
- How does tuning work? The big picture:

*Define a set of parameters to evaluate the model over*

**For** a set of parameters, do:

**For** each resampling iteration do:

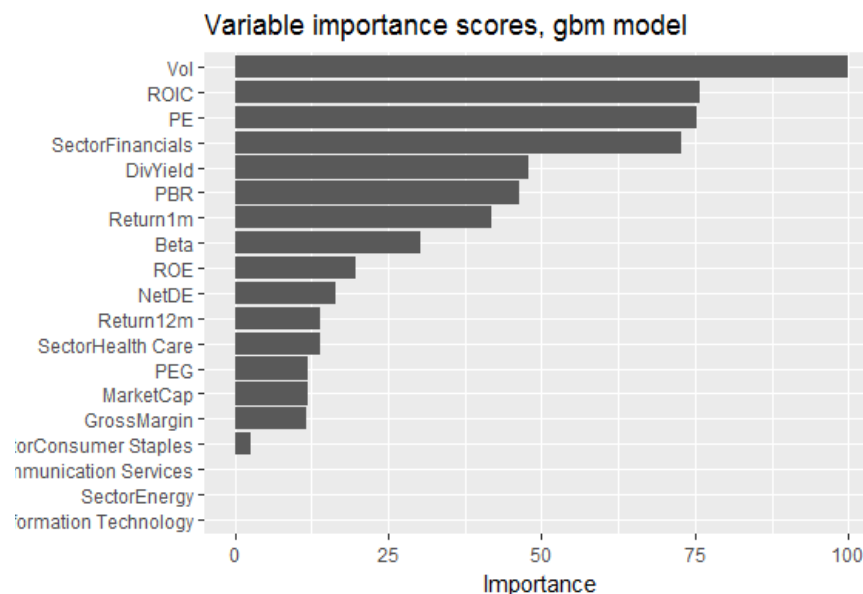
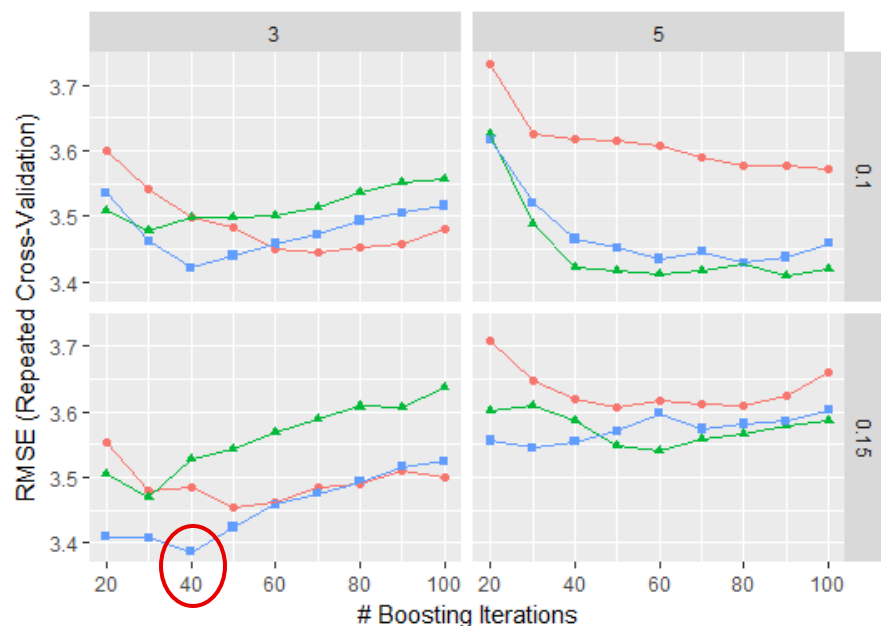
1. Holdout samples;
2. Fit model on remaining samples;
3. Predict on holdout samples;

Calculate average performance

*Determine the optimal set of parameters*

# Training a predictive model: Example (1)

- As a toy example, we fit a boosted tree model to predict forward return using a number of quant factors
- Pre-process the data: impute missing values, center and scale
- Define a grid of tuning parameters (4 in this case)
- Use repeated (10 times) 5 fold CV



# Training a predictive model: Example (2)

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- And we can do all of that in a few lines of code

```
# Define the tuning grid
gbm_grid <- expand.grid(
  n.trees = seq(20, 100, by = 10),
  interaction.depth = c(1, 3, 5),
  shrinkage = c(0.1, 0.15),
  n.minobsinnode = c(3, 5)
)
# Define the resampling scheme
my_cv_control <- trainControl(
  method = "repeatedcv",
  number = 5,          # number of folds
  repeats = 10,        # number of repeats
)
# Train the model
set.seed(20170627) # for reproducibility
gbm_fit <- train(
  FwdReturn ~ .,
  data = data,
  preprocess = c("nzv", "medianImpute", "center", "scale"),
  na.action = na.pass,
  method = "gbm",
  trControl = my_cv_control,
  tuneGrid = gbm_grid
)
# Plot the fit
ggplot(gbm_fit)
# Plot variable importance
gbm_imp <- varImp(gbm_fit)
ggplot(gbm_imp) +
  ggtitle("Variable importance scores, gbm model")
```

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