

Rob J Hyndman  
George Athanasopoulos

# FORECASTING

## PRINCIPLES AND PRACTICE

A comprehensive introduction to the latest forecasting methods using R. Learn to improve your forecast accuracy using dozens of real data examples.



3RD EDITION

 **OTexts**  
Oxford Texts in Finance and Probability

## 5. The forecaster's toolbox

### 5.10 Time series cross-validation

[OTexts.org/fpp3/](http://OTexts.org/fpp3/)

# Time series cross-validation

## Traditional evaluation

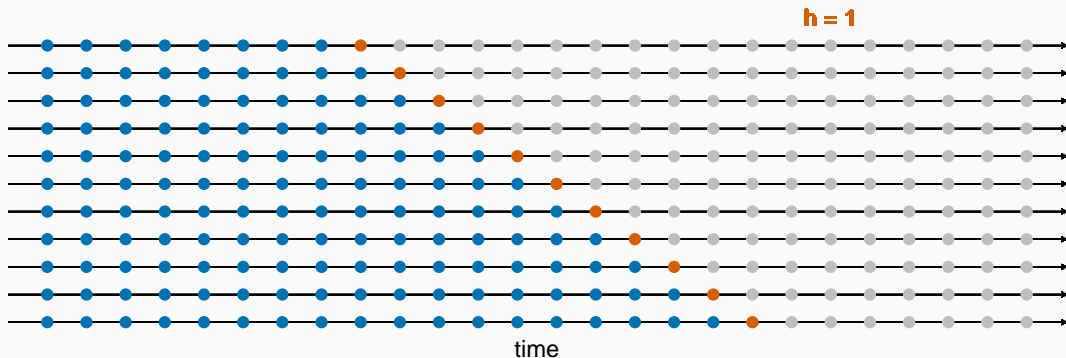


# Time series cross-validation

## Traditional evaluation



## Time series cross-validation

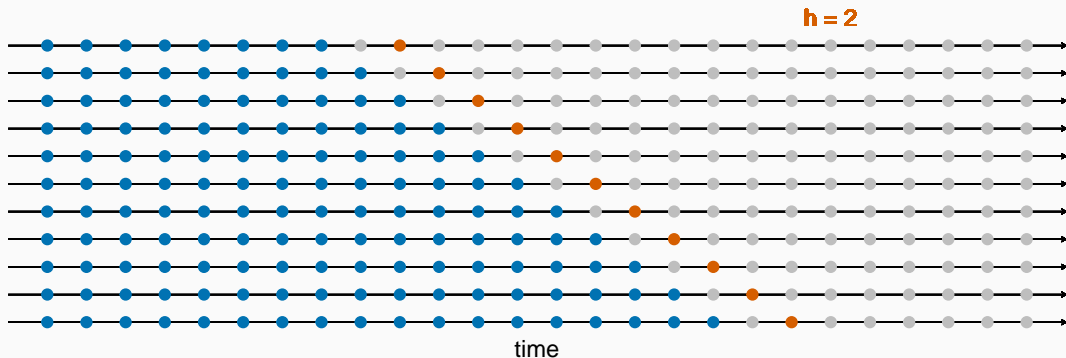


# Time series cross-validation

## Traditional evaluation



## Time series cross-validation

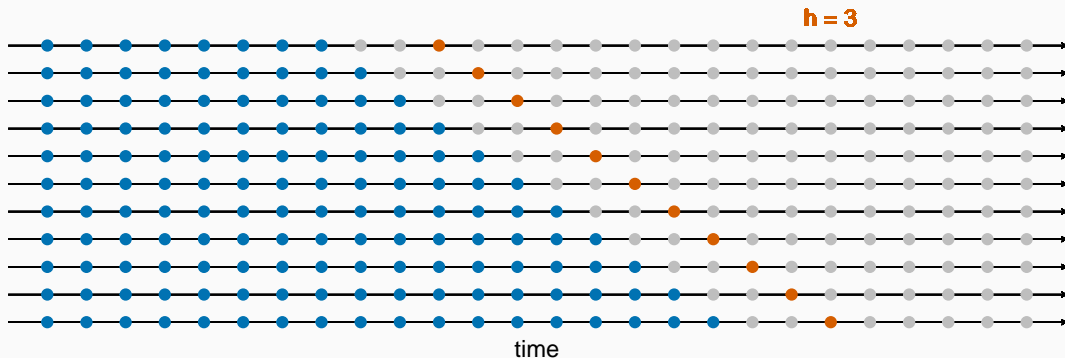


# Time series cross-validation

## Traditional evaluation



## Time series cross-validation

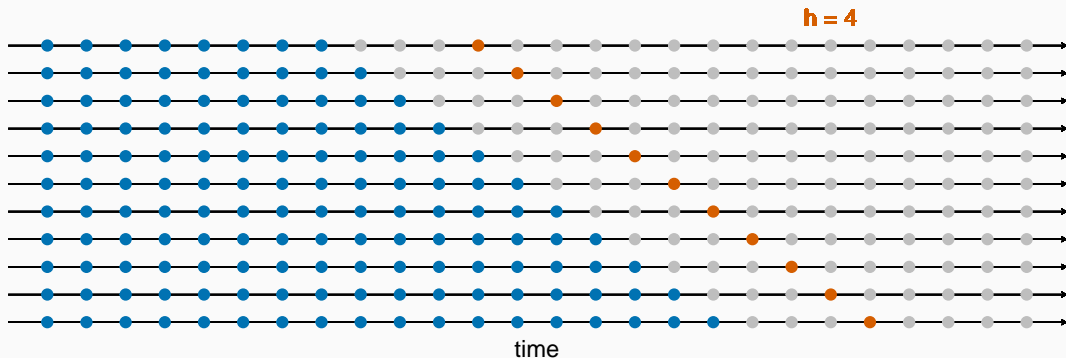


# Time series cross-validation

## Traditional evaluation



## Time series cross-validation

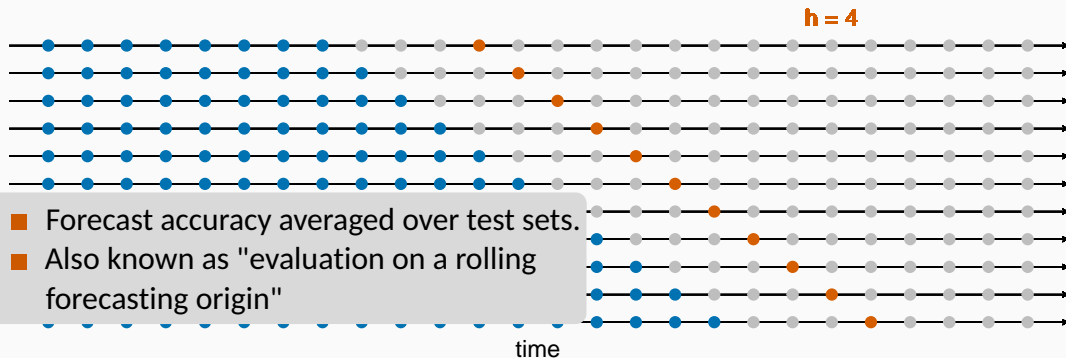


# Time series cross-validation

## Traditional evaluation



## Time series cross-validation



# Time series cross-validation

Stretch with a minimum length of 3, growing by 1 each step.

```
fb_stretch <- fb_stock |>
  stretch_tsibble(.init = 3, .step = 1) |>
  filter(.id != max(.id))
```

```
## # A tsibble: 790,650 x 4 [1]
## # Key:           .id [1,255]
##   Date          Close trading_day   .id
##   <date>        <dbl>         <int> <int>
## 1 2014-01-02    54.7             1     1
## 2 2014-01-03    54.6             2     1
## 3 2014-01-06    57.2             3     1
## 4 2014-01-02    54.7             1     2
## 5 2014-01-03    54.6             2     2
## 6 2014-01-06    57.2             3     2
## 7 2014-01-07    57.9             4     2
```



# Time series cross-validation

Estimate RW w/ drift models for each window.

```
fit_cv <- fb_stretch |>  
  model(RW(Close ~ drift()))
```

```
## # A mable: 1,255 x 3  
## # Key:      .id, Symbol [1,255]  
##      .id Symbol `RW(Close ~ drift())`  
##    <int> <chr>          <model>  
## 1      1 FB            <RW w/ drift>  
## 2      2 FB            <RW w/ drift>  
## 3      3 FB            <RW w/ drift>  
## 4      4 FB            <RW w/ drift>  
## # ... with 1,251 more rows
```

# Time series cross-validation

Produce one step ahead forecasts from all models.

```
fc_cv <- fit_cv |>  
  forecast(h = 1)
```

```
## # A fable: 1,255 x 5 [1]  
## # Key:      .id, Symbol [1,255]  
##      .id Symbol trading_day      Close .mean  
##    <int> <chr>      <dbl>      <dist> <dbl>  
## 1      1 FB          4 N(58, 5.8)  58.4  
## 2      2 FB          5 N(59, 2.7)  59.0  
## 3      3 FB          6 N(59, 1.9)  59.1  
## 4      4 FB          7 N(58, 2.2)  57.7  
## # ... with 1,251 more rows
```

# Time series cross-validation

```
# Cross-validated
fc_cv |> accuracy(fb_stock)
# Training set
fb_stock |>
  model(RW(Close ~ drift())) |>
  accuracy()
```

	RMSE	MAE	MAPE
Cross-validation	2.418	1.469	1.266
Training	2.414	1.465	1.261

A good way to choose the best forecasting model is to find the model with the smallest RMSE computed using time series cross-validation.