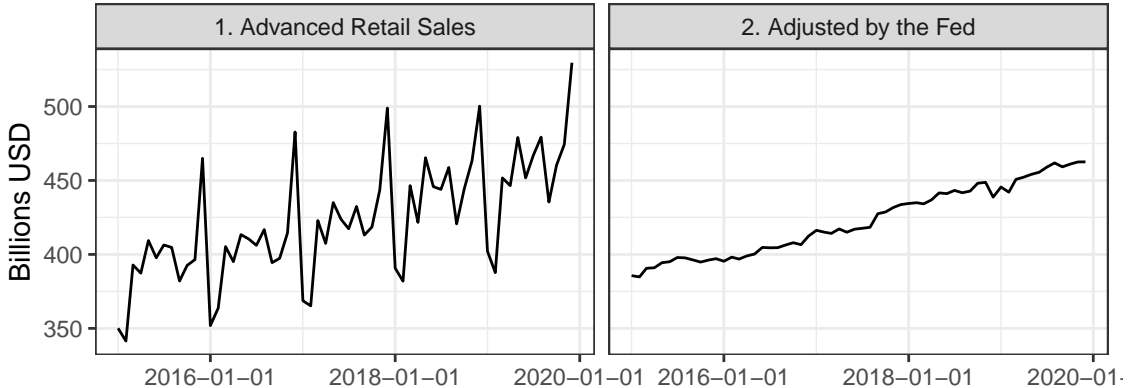# Today's Agenda

Fitting and evaluating linear trend models with seasonality effects

- Dataset: Advanced Retail Sales

Justin Leinaweaver (Spring 2022)

| date | year | month | advance_retail_sales | advance_retail_sales_adj |
|------|------|-------|---------------------|--------------------------|
| 16436 | 2015 | 1 | 350.067 | 385.672 |
| 16467 | 2015 | 2 | 341.459 | 384.783 |
| 16495 | 2015 | 3 | 392.848 | 390.642 |

"Seasonality is a characteristic of a time series in which the data experiences regular and predictable changes that recur every calendar year" (Investopedia 2020).


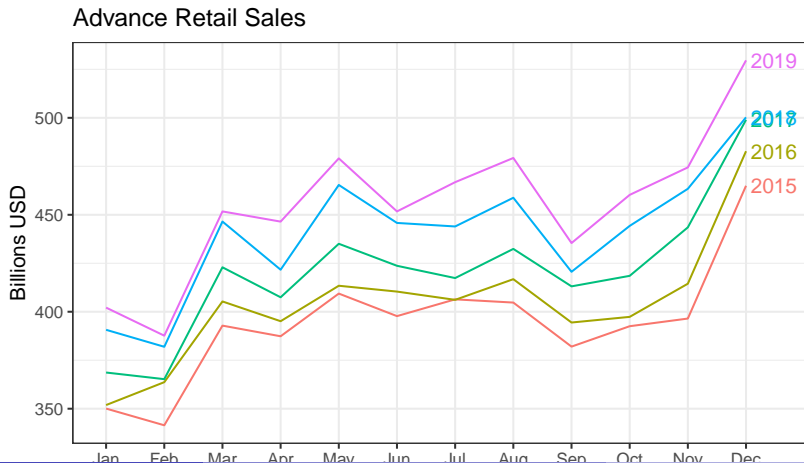
Advance Retail Sales
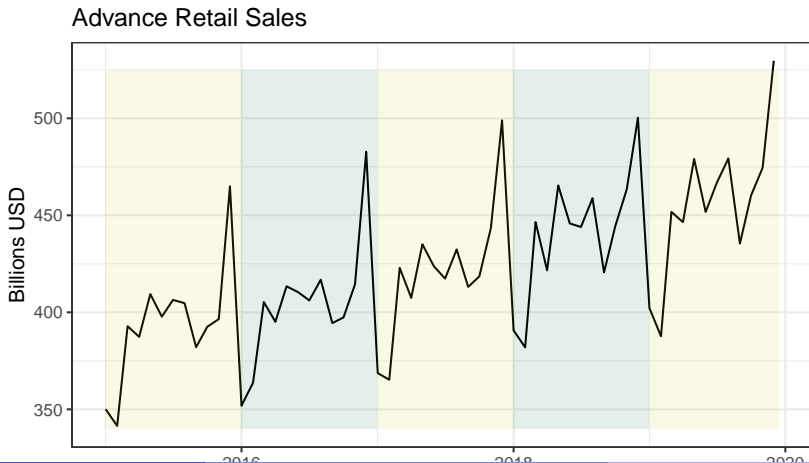
"Seasonality is a characteristic of a time series in which the data experiences regular and predictable changes that recur every calendar year" (Investopedia 2020).

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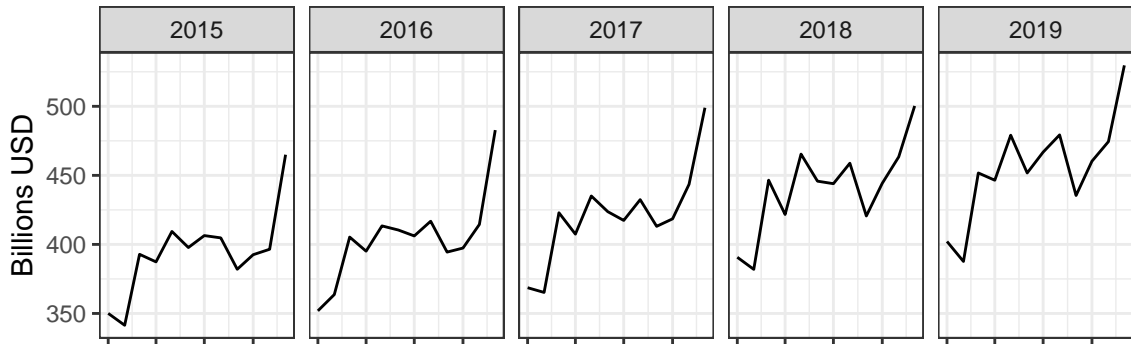


Advance Retail Sales
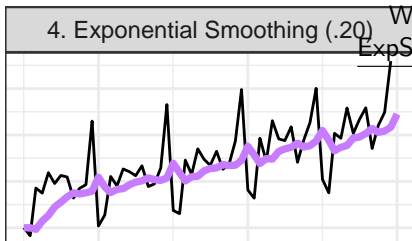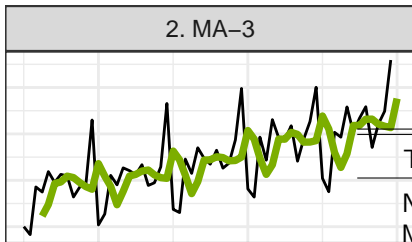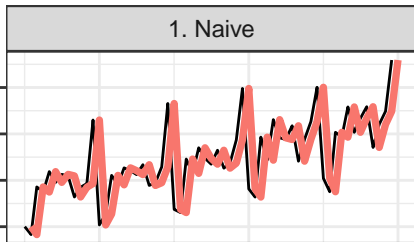
| Tools | MSE |
|---|---|
| Naive | 1629 |
| MA-3 | 1289 |
| WMA-3 | 1310 |
| ExpSmth (.2) | 1075 |

# Model 1

**Regress advanced retail sales on time period**

1. Fit the model (Time period = 1:60)
2. Visualize the model (line plot)
3. Predict the next 12 months

|                      | Retail Sales          |
| -------------------- | --------------------- |
| Time                 | 1.54*                 |
|                      | (0.22)                |
|                      |                       |
| Constant             | 375.76*               |
|                      | (7.62)                |
| Observations         | 60                    |
| Adjusted $R^2$       | 0.46                  |
| Residual Std. Error  | 29.13 (df = 58)       |
| F Statistic          | 50.61* (df = 1; 58)   |
| *Note:*              | *p<0.05               |
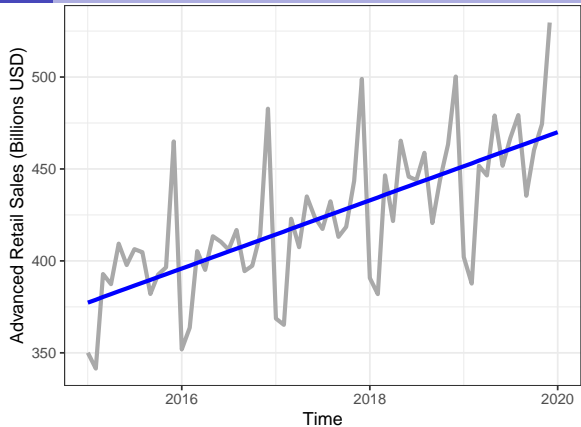


## Sales = 375.76 + 1.54 x Time

- Time = 61, 62, 63, 64, ...
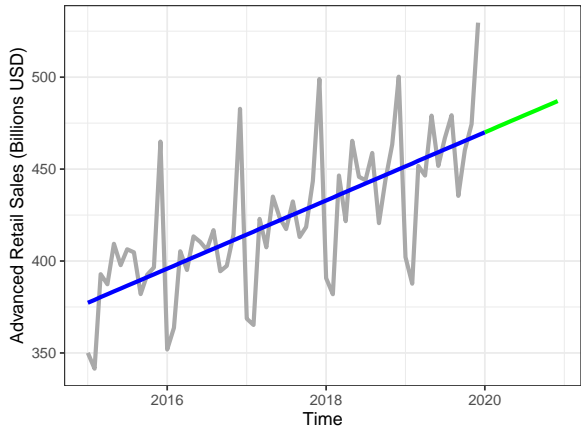
|  | Retail Sales |
| --- | --- |
| Time | 1.54* |
|  | (0.22) |
| Constant | 375.76* |
|  | (7.62) |
| Observations | 60 |
| Adjusted $R^2$ | 0.46 |
| Residual Std. Error | 29.13 (df = 58) |
| F Statistic | 50.61* (df = 1; 58) |
| *Note:* | *p<0.05 |



| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 470 | 472 | 473 | 475 | 476 | 478 | 479 | 481 | 482 | 484 | 485 | 487 |

# Fitting Linear Trend Models with OLS

| Tools | MSE |
|-------|-----|
| Naive | 1629 |
| WMA-3 | 1310 |
| MA-3 | 1289 |
| ExpSmth (.2) | 1075 |
| OLS Time | 820 |

## Model 2: Regress advanced retail sales on time period and season dummies

1. Fit the model
   - Time period = 1:60
   - Spring = '1' if Apr, May, Jun
   - Summer = '1' if Jul, Aug, Sep
   - Fall = '1' if Oct, Nov, Dec

2. Visualize the model (line plot)

3. Predict the next 12 months

# Fitting Linear Tren

| | date | year | month | advance |
|---|---|---|---|---|
| 2 | 2015-01-01 | 2015 | 1 | |
| 3 | 2015-02-01 | 2015 | 2 | |
| 4 | 2015-03-01 | 2015 | 3 | |
| 5 | 2015-04-01 | 2015 | 4 | |
| 6 | 2015-05-01 | 2015 | 5 | |
| 7 | 2015-06-01 | 2015 | 6 | |
| 8 | 2015-07-01 | 2015 | 7 | |
| 9 | 2015-08-01 | 2015 | 8 | |
| 10 | 2015-09-01 | 2015 | 9 | |
| 11 | 2015-10-01 | 2015 | 10 | |
| 12 | 2015-11-01 | 2015 | 11 | |
| 13 | 2015-12-01 | 2015 | 12 | |

# Fitting Linear Tren

| | date | year | month | advance |
|---|---|---|---|---|
| 1 | date | year | month | advance |
| 2 | 2015-01-01 | 2015 | 1 | |
| 3 | 2015-02-01 | 2015 | 2 | |
| 4 | 2015-03-01 | 2015 | 3 | |
| 5 | 2015-04-01 | 2015 | 4 | |
| 6 | 2015-05-01 | 2015 | 5 | |
| 7 | 2015-06-01 | 2015 | 6 | |
| 8 | 2015-07-01 | 2015 | 7 | |
| 9 | 2015-08-01 | 2015 | 8 | |
| 10 | 2015-09-01 | 2015 | 9 | |
| 11 | 2015-10-01 | 2015 | 10 | |
| 12 | 2015-11-01 | 2015 | 11 | |
| 13 | 2015-12-01 | 2015 | 12 | |
| | 2016-01-01 | 2016 | 1 | |

# Fitting Linear Tren

| | date | year | month | advance |
|---|---|---|---|---|
| 1 | | | | |
| 2 | 2015-01-01 | 2015 | 1 | |
| 3 | 2015-02-01 | 2015 | 2 | |
| 4 | 2015-03-01 | 2015 | 3 | |
| 5 | 2015-04-01 | 2015 | 4 | |
| 6 | 2015-05-01 | 2015 | 5 | |
| 7 | 2015-06-01 | 2015 | 6 | |
| 8 | 2015-07-01 | 2015 | 7 | |
| 9 | 2015-08-01 | 2015 | 8 | |
| 10 | 2015-09-01 | 2015 | 9 | |
| 11 | 2015-10-01 | 2015 | 10 | |
| 12 | 2015-11-01 | 2015 | 11 | |
| 13 | 2015-12-01 | 2015 | 12 | |
| 14 | 2016-01-01 | 2016 | 1 | |

# Fitting Linear Tren

| | date | year | month | advance |
|---|---|---|---|---|
| 1 | date | year | month | advance |
| 2 | 2015-01-01 | 2015 | 1 | |
| 3 | 2015-02-01 | 2015 | 2 | |
| 4 | 2015-03-01 | 2015 | 3 | |
| 5 | 2015-04-01 | 2015 | 4 | |
| 6 | 2015-05-01 | 2015 | 5 | |
| 7 | 2015-06-01 | 2015 | 6 | |
| 8 | 2015-07-01 | 2015 | 7 | |
| 9 | 2015-08-01 | 2015 | 8 | |
| 10 | 2015-09-01 | 2015 | 9 | |
| 11 | 2015-10-01 | 2015 | 10 | |
| 12 | 2015-11-01 | 2015 | 11 | |
| 13 | 2015-12-01 | 2015 | 12 | |
| | 2016-01-01 | 2016 | 1 | |

## Model 2: Regress advanced retail sales on time period and season dummies
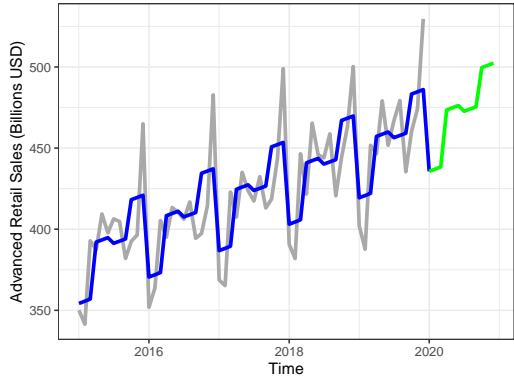
1. Fit the model
   - Time period $= 1:60$
   - Spring $= '1'$ if Apr, May, Jun
   - Summer $= '1'$ if Jul, Aug, Sep
   - Fall $= '1'$ if Oct, Nov, Dec

2. Visualize the model (line plot)

3. Predict the next 12 months

|                     | Retail Sales           |
| ------------------- | ---------------------- |
| Time                | 1.36*                  |
|                     | (0.17)                 |
| Spring              | 33.73*                 |
|                     | (8.43)                 |
| Summer              | 28.89*                 |
|                     | (8.47)                 |
| Fall                | 51.73*                 |
|                     | (8.56)                 |
| Constant            | 352.90*                |
|                     | (7.49)                 |
| Observations        | 60                     |
| Adjusted $R^2$      | 0.66                   |
| Residual Std. Error | 23.03 (df = 55)        |
| F Statistic         | 29.70* (df = 4; 55)    |
| *Note:*             | *p<0.05                |



Predictions
c(436, 437, 438, 473, 475, 476, 473, 474, 475, 500, 501, 502)

# Fitting Linear Trend Models with OLS

| Tools | MSE |
|---|---|
| Naive | 1629 |
| WMA-3 | 1310 |
| MA-3 | 1289 |
| ExpSmth (.2) | 1075 |
| OLS Time | 820 |
| OLS Time and Season | 486 |
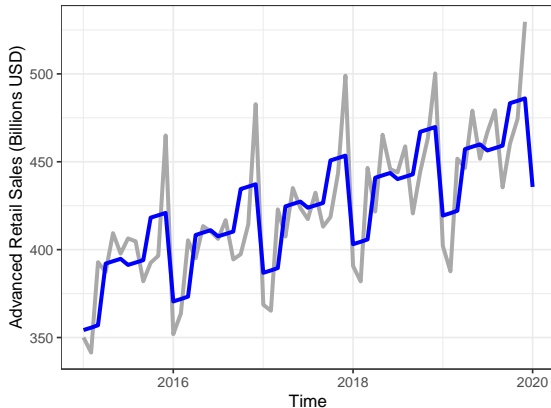
# Model 3: Regress advanced retail sales on time period and monthly dummies

1. Fit the model
   - Time period $= 1:60$
   - Month dummies (x 11)

2. Visualize the model (line plot)

3. Predict the next 12 months

# Fitting Linear Tren

| | A | B | C | D |
|---|---|---|---|---|
| 1 | date | year | month | advance_reta |
| 2 | 2015-01-01 | 2015 | 1 | |
| 3 | 2015-02-01 | 2015 | 2 | |
| 4 | 2015-03-01 | 2015 | 3 | |
| 5 | 2015-04-01 | 2015 | 4 | |
| 6 | 2015-05-01 | 2015 | 5 | |
| 7 | 2015-06-01 | 2015 | 6 | |
| 8 | 2015-07-01 | 2015 | 7 | |
| 9 | 2015-08-01 | 2015 | 8 | |
| 10 | 2015-09-01 | 2015 | 9 | |
| 11 | 2015-10-01 | 2015 | 10 | |
| 12 | 2015-11-01 | 2015 | 11 | |
| 13 | 2015-12-01 | 2015 | 12 | |
| 14 | 2016-01-01 | 2016 | 1 | |

|                      | Retail Sales           |
|----------------------|------------------------|
| Time                 | 1.33*                  |
|                      | (0.05)                 |
| Constant             | 339.55*                |
|                      | (3.31)                 |
| Observations         | 60                     |
| Adjusted $R^2$       | 0.97                   |
| Residual Std. Error  | 6.81 (df = 47)         |
| F Statistic          | 161.59* (df = 12; 47)  |
| *Note:*              | *p<0.05                |
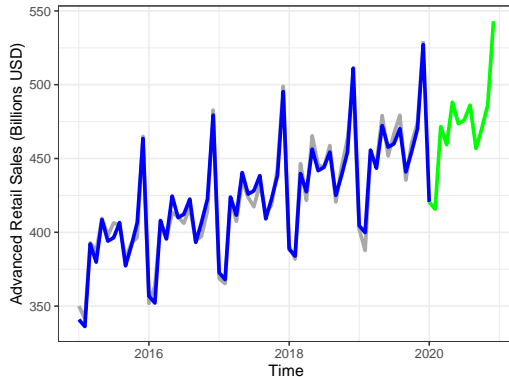


Predictions = 420, 416, 472, 459, 488, 474, 476, 486, 457, 470, 486, 543

- Month coefficients omitted from the table.

# Fitting Linear Trend Models with OLS

| Tools | MSE |
|---|---|
| Naive | 1629 |
| WMA-3 | 1310 |
| MA-3 | 1289 |
| ExpSmth (.2) | 1075 |
| OLS Time | 820 |
| OLS Time and Season | 486 |
| OLS Time and Month | 36 |
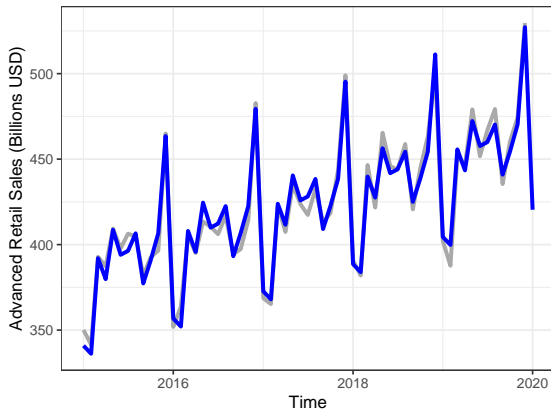
# Predict the next 12 months of new home sales
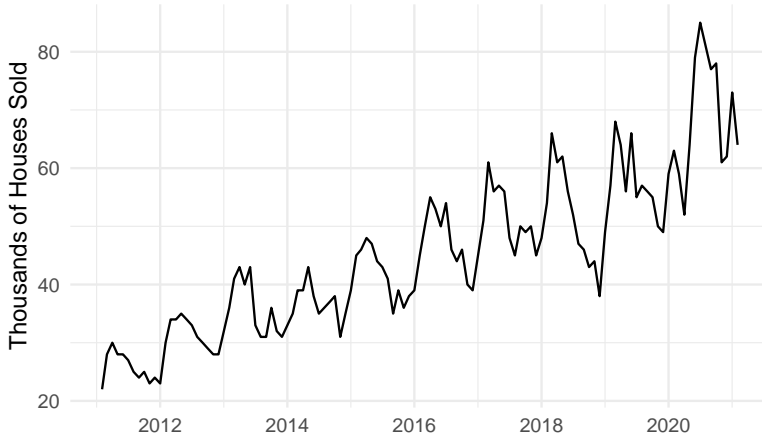


**Regress new home sales on time and season dummies**
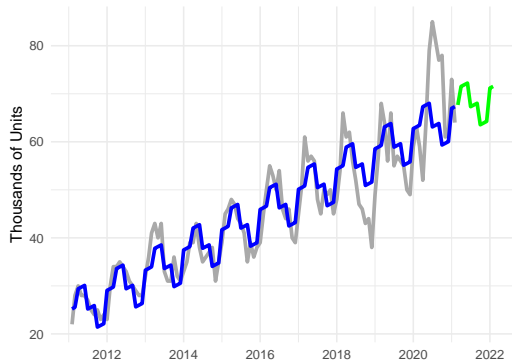
|                        | New Home Sales          |
| ---------------------- | ----------------------- |
| Time                   | 0.35*                   |
|                        | (0.01)                  |
| Spring                 | 3.50*                   |
|                        | (1.44)                  |
| Summer                 | −1.76                   |
|                        | (1.44)                  |
| Fall                   | −6.58*                  |
|                        | (1.44)                  |
| Constant               | 24.84*                  |
|                        | (1.35)                  |
| Observations           | 121                     |
| Adjusted $R^2$         | 0.83                    |
| Residual Std. Error    | 5.62 (df = 116)         |
| F Statistic            | 151.41* (df = 4; 116)   |
| *Note:*                | *p<0.05                 |

|                       | New Home Sales           |
| --------------------- | ------------------------ |
| Time                  | $0.35^*$                 |
|                       | (0.01)                   |
| Spring                | $3.50^*$                 |
|                       | (1.44)                   |
| Summer                | $-1.76$                  |
|                       | (1.44)                   |
| Fall                  | $-6.58^*$                |
|                       | (1.44)                   |
| Constant              | $24.84^*$                |
|                       | (1.35)                   |
| Observations          | 121                      |
| Adjusted $R^2$        | 0.83                     |
| Residual Std. Error   | 5.62 (df = 116)          |
| F Statistic           | $151.41^*$ (df = 4; 116) |

*Note:*        $^*p<0.05$

| Time | Date       | Predictions |
| ---- | ---------- | ----------- |
| 122  | 2021-03-01 | 68          |
| 123  | 2021-04-01 | 72          |
| 124  | 2021-05-01 | 72          |
| 125  | 2021-06-01 | 72          |
| 126  | 2021-07-01 | 67          |
| 127  | 2021-08-01 | 68          |
| 128  | 2021-09-01 | 68          |
| 129  | 2021-10-01 | 64          |
| 130  | 2021-11-01 | 64          |
| 131  | 2021-12-01 | 64          |
| 132  | 2022-01-01 | 71          |
| 133  | 2022-02-01 | 72          |