FORECASTING PRODUCT DEMAND IN R

# Price elasticity

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# Price vs. Demand

- **Price elasticity** is the economic measure of how much demand "reacts" to changes in price

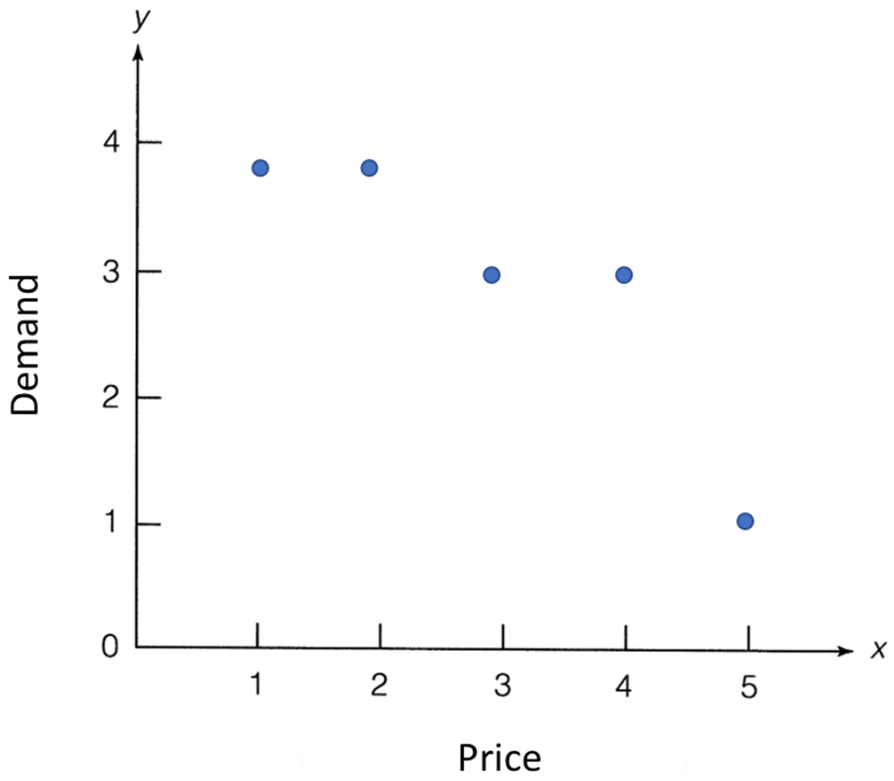
- As price changes, it is expected that demand changes as well, but how much?

$$\text{Price Elasticity} = \frac{\%\text{Change in Demand}}{\%\text{Change in Price}}$$

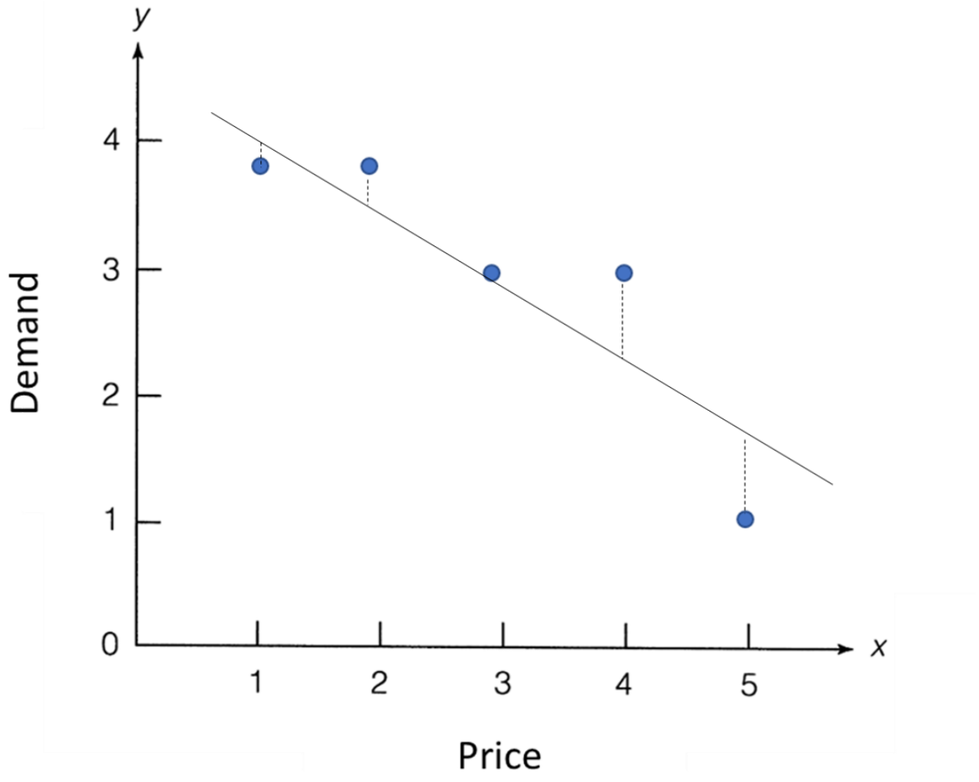
# Elastic vs. Inelastic

- **Elastic** products are ones that have % changes in demand larger than the % change in price ($\text{Price Elasticity} > 1$)
- **Inelastic** products are ones that have % changes in demand smaller than the % change in price ($\text{Price Elasticity} < 1$)
- **Unit elastic** products are ones that have % changes in demand equal to the % change in price ($\text{Price Elasticity} = 1$)

# Linear Regression



# Linear Regression



# Price Elasticity Example

```
M_hi <- as.vector(bev_xts_train[,"M.hi"])

M_hi_p <- as.vector(bev_xts_train[,"M.hi.p"])

M_hi_train <- data.frame(log(M_hi), log(M_hi_p))

colnames(M_hi_train) <- c("log_sales", "log_price")

model_M_hi <- lm(log_sales ~ log_price, data = M_hi_train)

model_M_hi

Call:
lm(formula = log_sales ~ log_price)

Coefficients:
(Intercept)  log_price
     8.9907      -0.7138
```

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# Let's practice!

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# Seasonal / holiday / promotional effects

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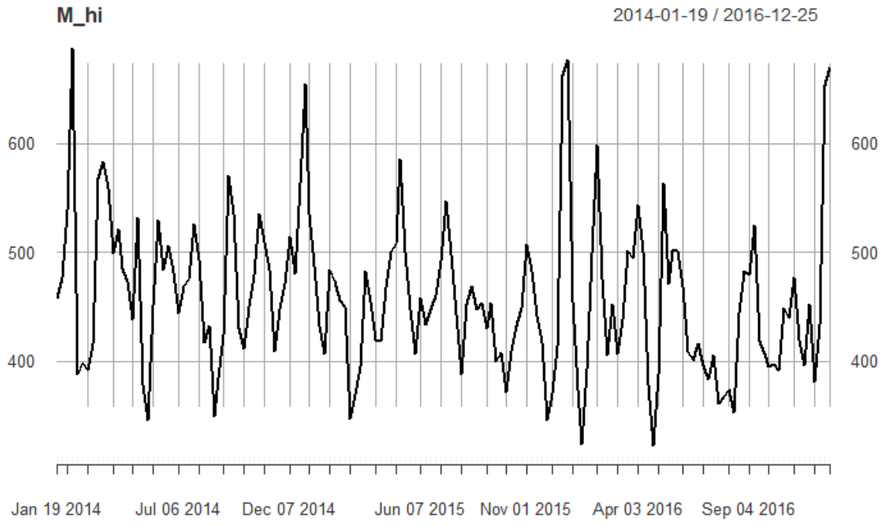
# Influencers of Demand

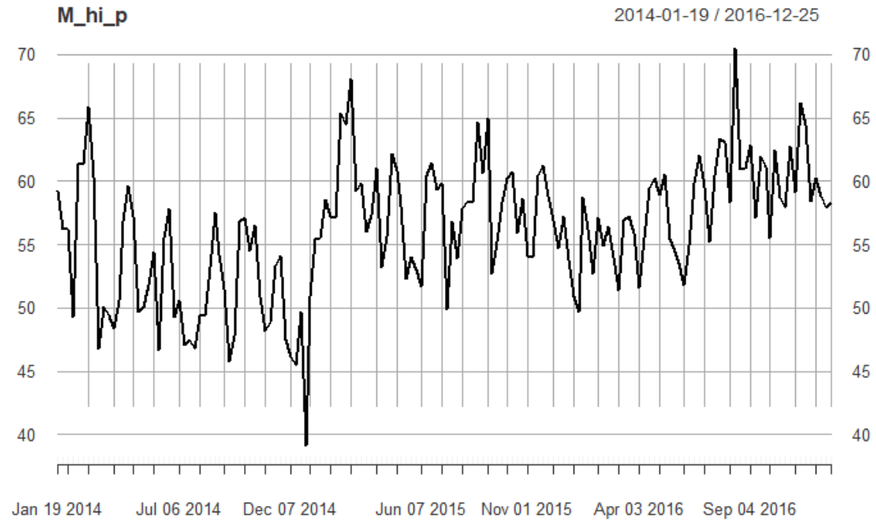
- Seasonal effects
  - Examples: Winter coats, bathing suits, school supplies, etc.
- Holiday effects
  - Examples: Retail sales, holiday decorations, candy, etc.
- Promotion effects
  - Examples: Digital marketing, shelf optimization, etc.

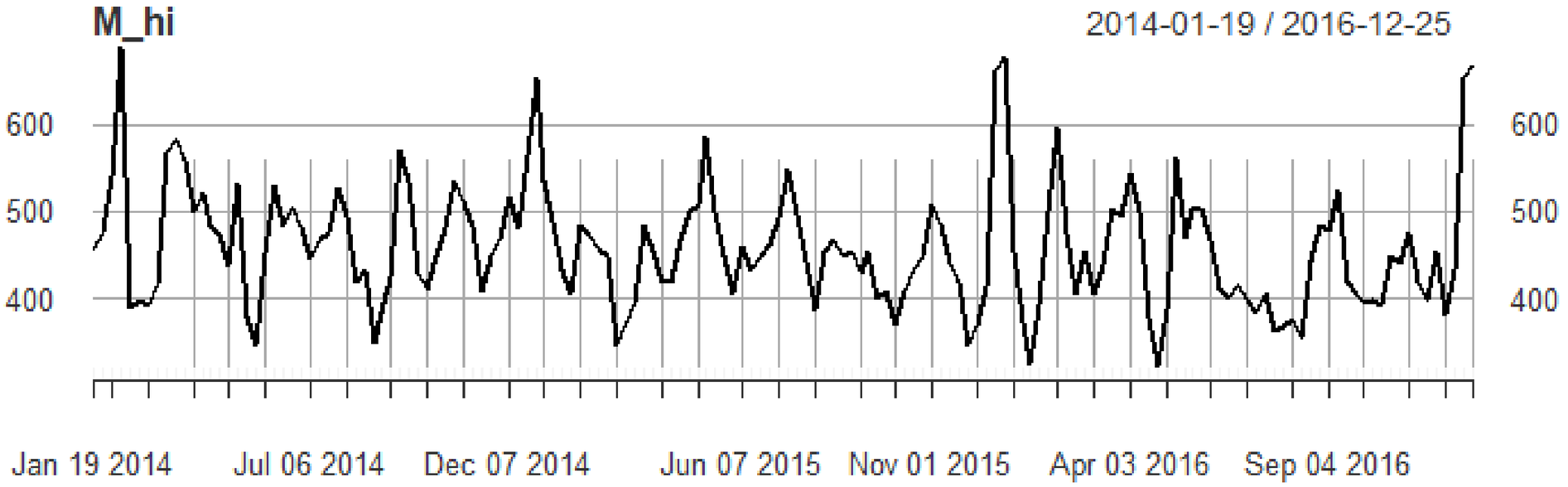
# Seasonal / Holiday / Promotion?

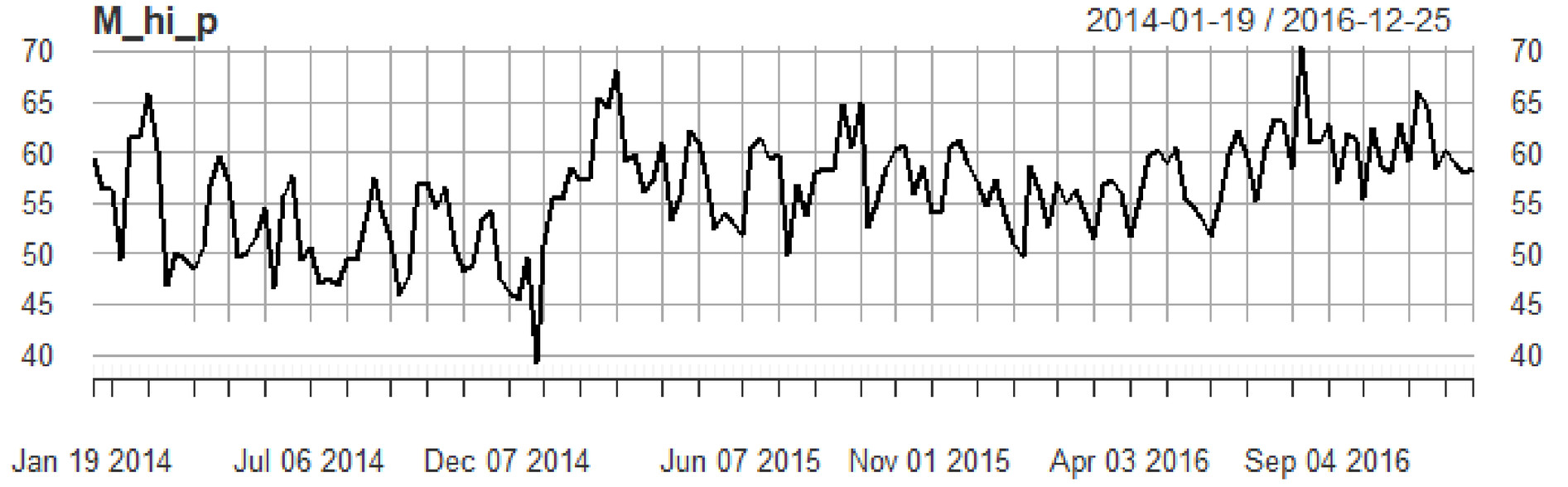
```
plot(M_hi)
```




```
plot(M_hi_p)
```




M_hi
2014-01-19 / 2016-12-25
600
500
400
Jan 19 2014
Jul 06 2014
Dec 07 2014
Jun 07 2015
Nov 01 2015
Apr 03 2016
Sep 04 2016


M_hi_p
2014-01-19 / 2016-12-25
70
65
60
55
50
45
40
Jan 19 2014
Jul 06 2014
Dec 07 2014
Jun 07 2015
Nov 01 2015
Apr 03 2016
Sep 04 2016

# Linear Regression! Again...

- Linear regression helps us evaluate the relationship between many factors and demand, not just price.
- Add seasonal, holiday, and promotion effects to previous regression!
- Any of these effects **statistically significant**?
    - Are the effects due to random chance or not?

# Creating Effects Example

```
v.dates <- as.Date(c("2014-02-09", "2015-02-08", "2016-02-07"))
valentine <- as.xts(rep(1, 3), order.by = v.dates)

dates_train <- seq(as.Date("2014-01-19"), length = 154, by = "weeks")
valentine <- merge(valentine, dates_train, fill = 0)

head(valentine, n = 5)
           valentine
2014-01-19         0
2014-01-26         0
2014-02-02         0
2014-02-09         1
2014-02-16         0
```

# Adding Effects Example

```
M_hi_train <- data.frame(M_hi_train, as.vector(valentine))

model_M_hi_full <- lm(log_sales ~ log_price + valentine, data = M_hi_train)

summary(model_M_hi_full)
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.93102    0.44693  19.983  < 2e-16 ***
log_price   -0.70010    0.11103  -6.306    3e-09 ***
valentine    0.22942    0.07547   3.040  0.00279 **

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

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# Forecasting with regression

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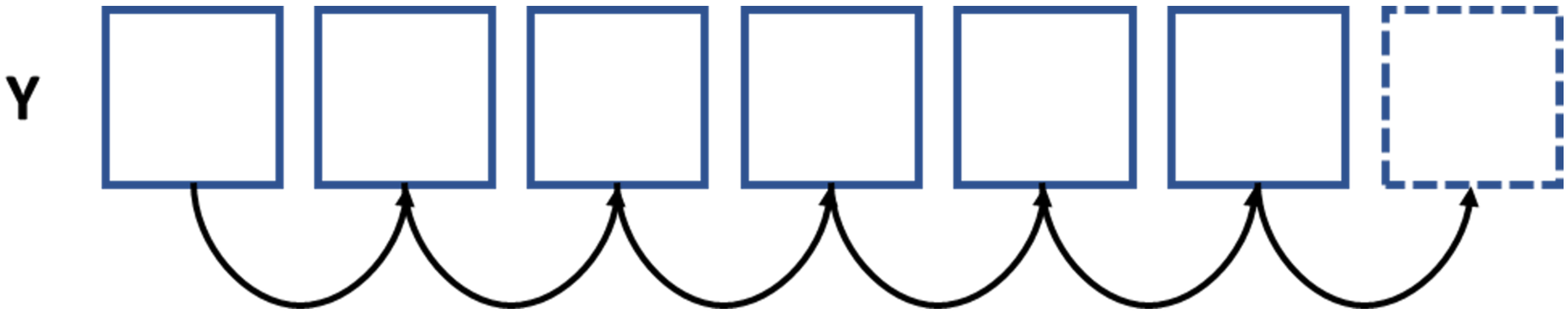
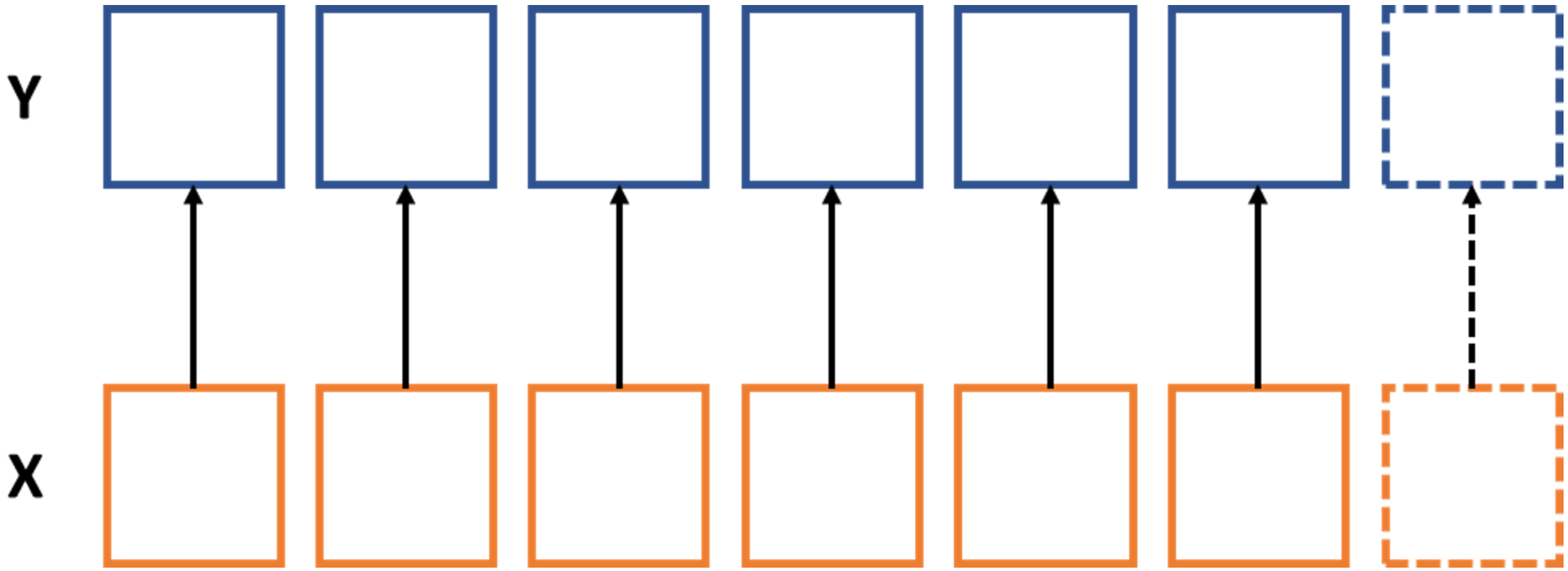
# Forecasting with Time Series



# Forecasting with Regression



# Future Input Variables

- How to "predict" future input variables?
  - Holidays and Promotions: NO WORRIES - we know these ahead of time
- Prices - Possible problem!
  - Prices set ahead of time (our assumption)
  - Forecast future prices with time series!

# Future Input Variables Example

```
v.dates_v <- as.Date("2017-02-12")

valentine_v <- as.xts(1, order.by = v.dates_v)
dates_valid <- seq(as.Date("2017-01-01"), length = 22, by = "weeks")

valentine_v <- merge(valentine_v, dates_valid, fill = 0)

l_M_hi_p_valid <- log(bev_xts_valid[,"M.hi.p"])

model_M_valid <- data.frame(as.vector(l_M_hi_p_valid), as.vector(valentine_v))
colnames(model_M_valid) <- c("log_price", "valentine")
```

# Future Regression Example

```
pred_M_hi <- predict(model_M_hi_full, model_M_valid)

head(pred_M_hi)

       1        2        3        4        5        6
6.128652 6.129163 5.975786 6.030943 6.048169 6.099596

pred_M_hi <- exp(pred_M_hi)

head(pred_M_hi)

       1        2        3        4        5        6
458.8170 459.0519 393.7775 416.1070 423.3371 445.6778
```

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