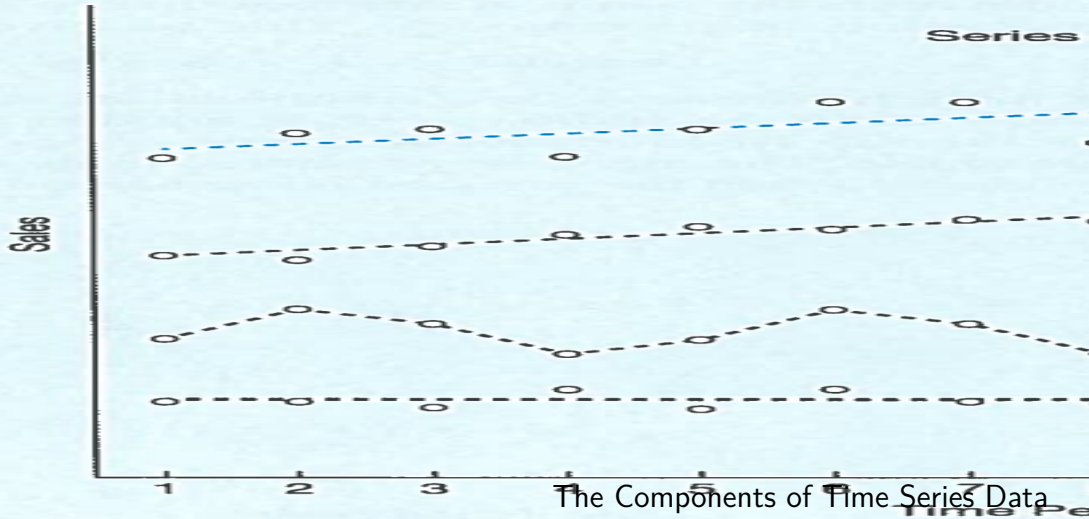


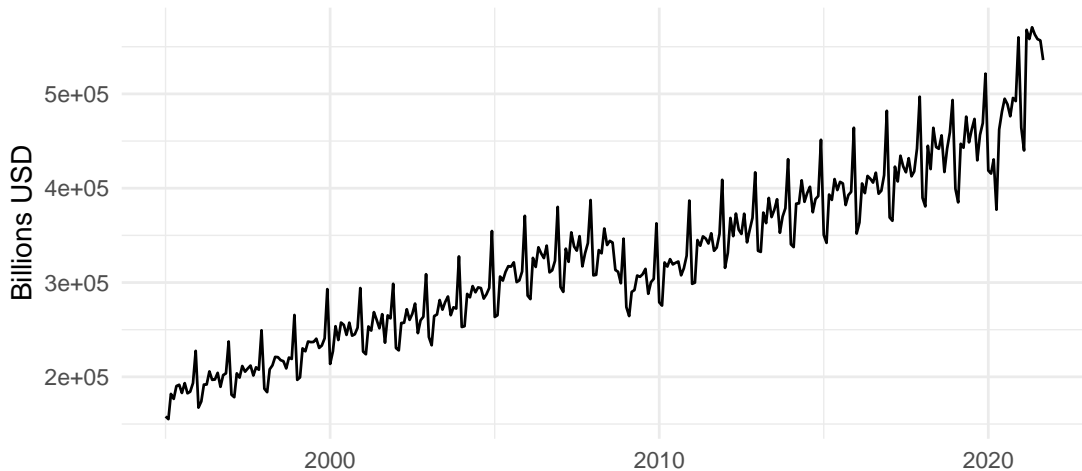
# Today's Agenda

1. Review the components of time series data
2. Evaluate four forecasting tools:
  - Naïve
  - Moving Average
  - Weighted Moving Average
  - Exponential Smoothing



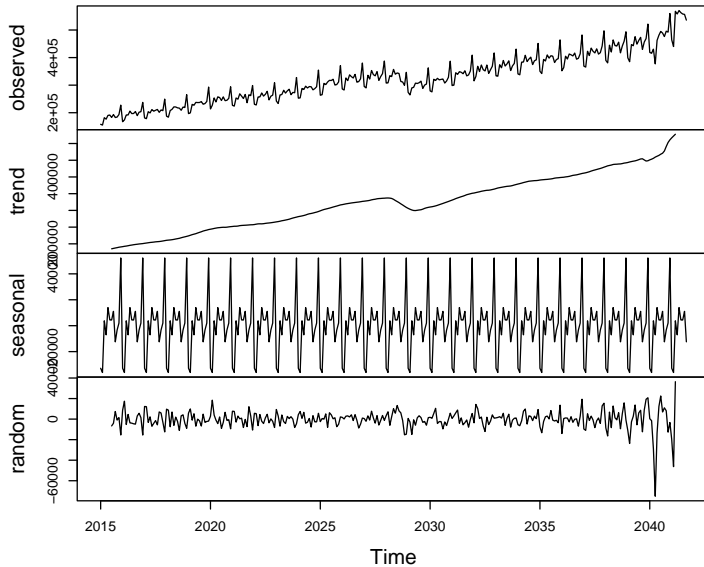
The Components of Time Series Data  
(Render, Stair, Jr., Hanna and Hale 2018)

## Advance Retail Sales

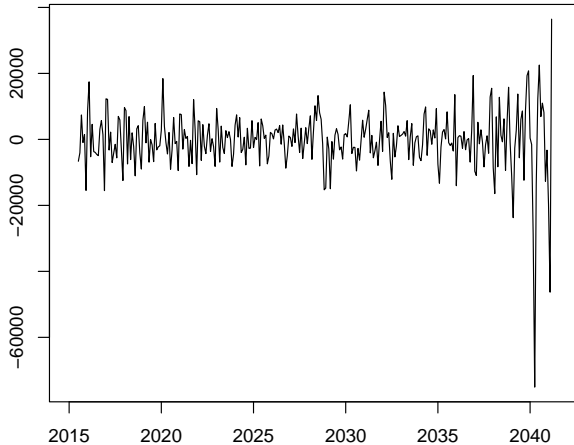


Source: U.S. Census Bureau

## Decomposition of additive time series



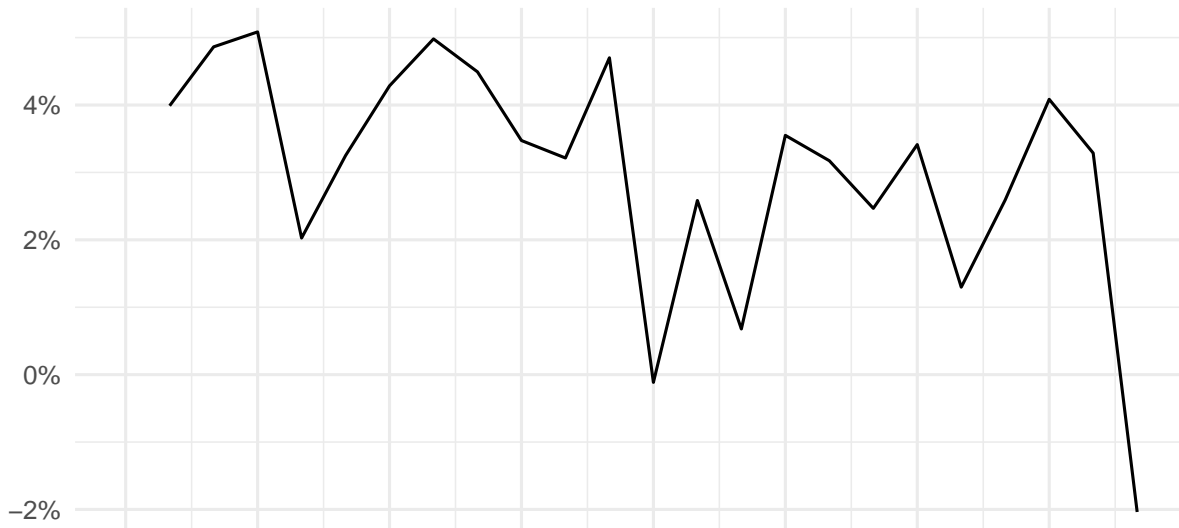
## Random Variation



## Random Variation Models

- ① Naïve Forecast
- ② Moving Average
- ③ Weighted Moving Average
- ④ Exponential Smoothing

## Rate of Change in GDP (Missouri)



## Forecast 1: Naive Forecast

Set forecast to the last observation

- $\text{Forecast}_{time+1} = \text{Actual}_{time}$

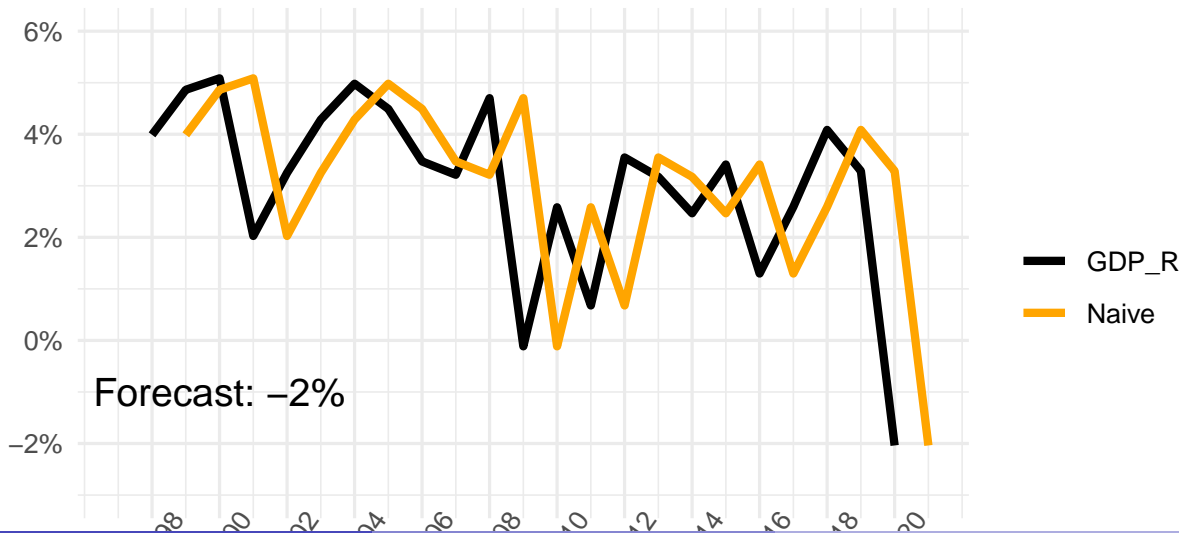
## Forecast 1: Naive Forecast

A		
1	Time	
2	1998	
3	1999	
4	2000	

Calculate the forecast



## Rate of Change in GDP (Missouri)



# Forecast Accuracy: Mean Squared Error (MSE)

- 1 Calculate the forecast error
  - Forecast Error = Actual Value - Forecast Value
- 2 Square each forecast error
- 3 Calculate the mean of the squared errors

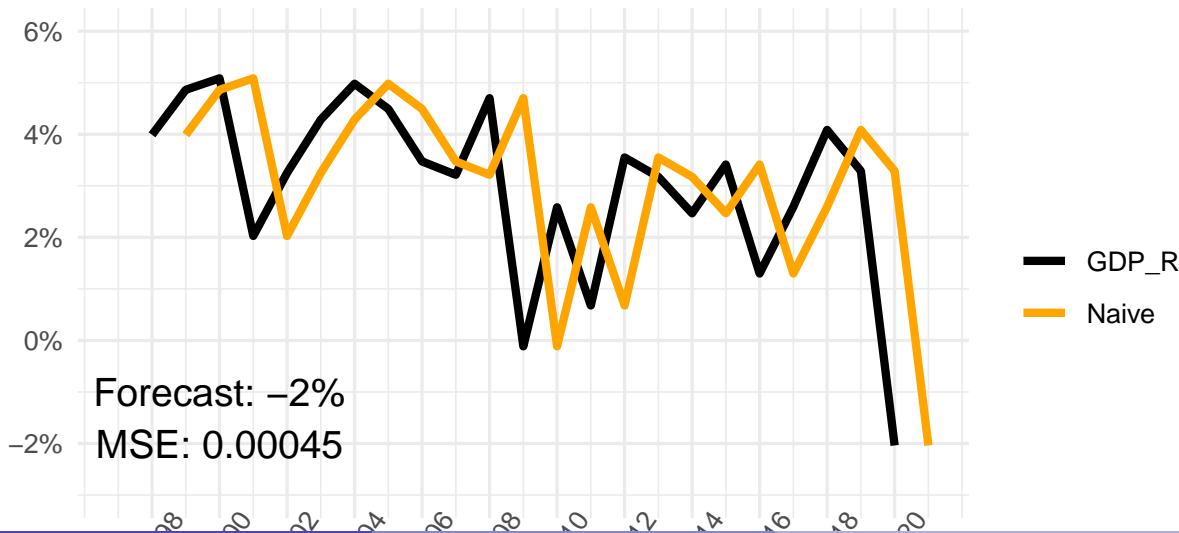
$$MSE = \frac{\sum (Error)^2}{n}$$

$$MSE = \frac{\Sigma (Error)^2}{n}$$

	A	B
1	Time	Actual
2	1998	$X_{1998}$
3	1999	$X_{1999}$
4	2000	$X_{2000}$

$$MSE = AVERAGE(D3:D4)$$

## Rate of Change in GDP (Missouri)



## Forecast 2: Moving

$$F_{t+1} = \frac{Y_t + \dots + Y_{t-n+1}}{n}$$

$F_{t+1}$  = forecast

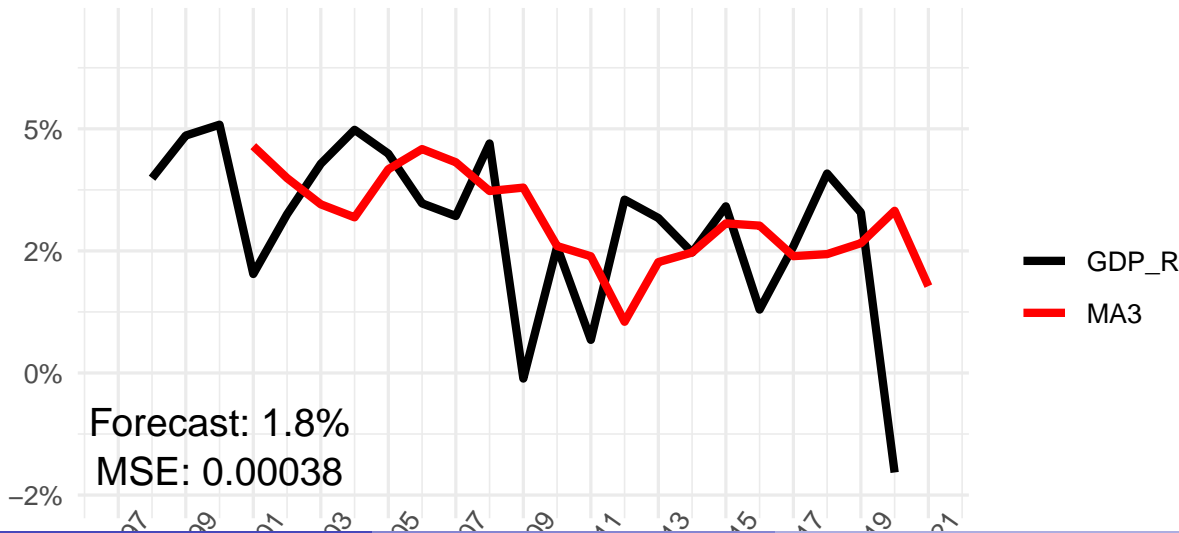
$Y_t$  = actual v

$n$  = number

## Forecast 2: Moving A

		A	B
		Time	Actual
	1	1998	$X_{1998}$
	2	1999	$X_{1999}$
	3	2000	$X_{2000}$
	4	2001	$X_{2001}$
	5	2002	$X_{2002}$
	6	2003	$X_{2003}$

## Rate of Change in GDP (Missouri)



## Forecast 3: Weighted Moving Average Forecast

$$F_{t+1} = \frac{\sum(\text{Weight in period } i)(\text{Actual value in period } i)}{\sum(\text{Weights})}$$



## Forecast 3: Weighted Moving Average Forecast

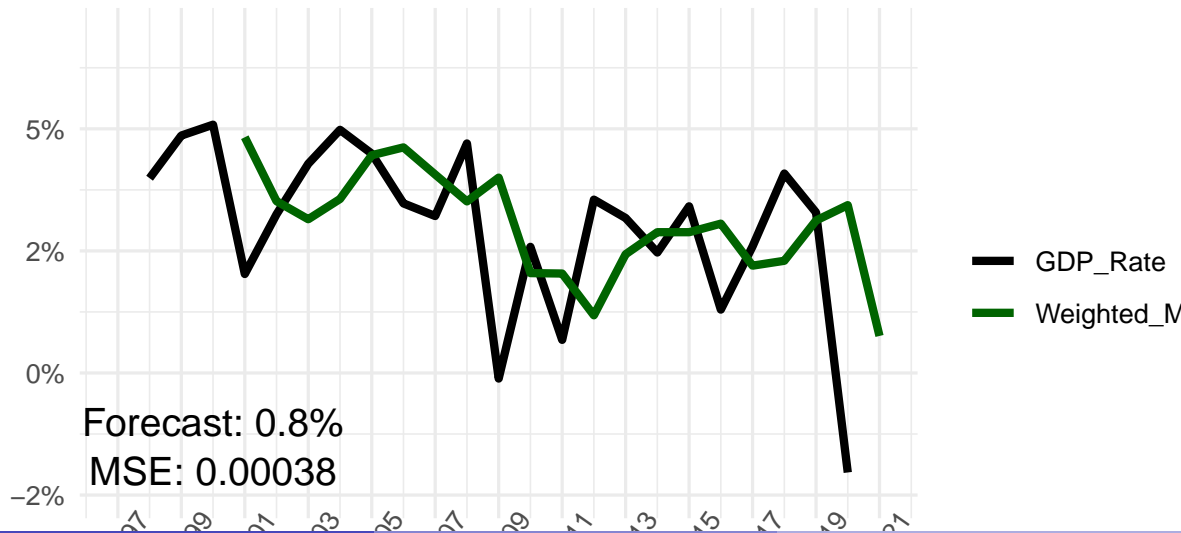
$$F_{t+1} = \frac{\sum(\text{Weight in period } i)(\text{Actual value in period } i)}{\sum(\text{Weights})}$$

$$\text{Forecast}_t = \frac{(\text{Actual}_{t-1} \times 3 + \text{Actual}_{t-2} \times 2 + \text{Actual}_{t-3} \times 1)}{6}$$

## Forecast 3: Weighted

1	A	B
	Time	Actual
2	1998	$X_{1998}$
3	1999	$X_{1999}$
4	2000	$X_{2000}$
5	2001	$X_{2001}$
6	2002	$X_{2002}$
7	2003	$X_{2003}$

## Rate of Change in GDP (Missouri)



## Forecast 4: Exponential Smoothing

$$F_{t+1} =$$

$$F_{t+1} = \text{new forecast}$$

$$F_t = \text{previous forecast}$$

$$\alpha = \text{smoothing constant}$$

$$Y_t = \text{previous period's actual value}$$

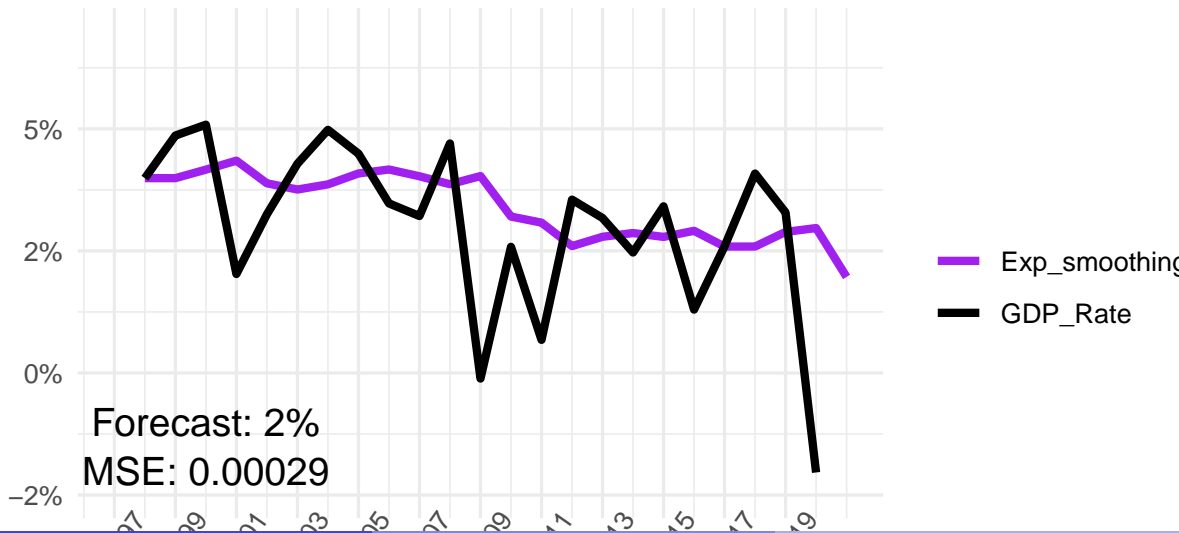
## Forecast 4: Exponential

	A	B
1	Time	Actual
2	1998	$X_{1998}$
3	1999	$X_{1999}$
4	2000	$X_{2000}$
5	2001	$X_{2001}$
6	2002	$X_{2002}$
7	2003	$X$

# Forecast 4: Exponential

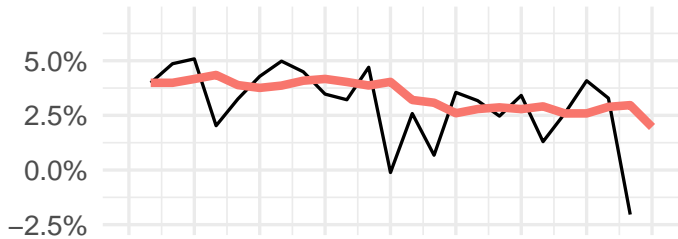
	A	B
1	Time	Actual
2	1998	$X_{1998}$
3	1999	$X_{1999}$
4	2000	$X_{2000}$
5	2001	$X_{2001}$
6	2002	$X_{2002}$
7	2003	$\gamma$

## Rate of Change in GDP (Missouri)



GDP (Rate)

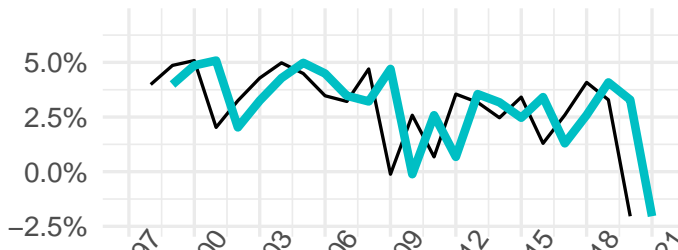
Exp\_smoothing20



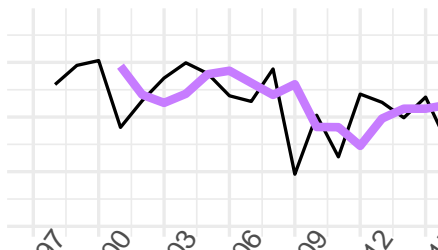
MA3



Naive



Weighted\_MA3





Forecast Tool	MSE	Prediction
Naive Forecast	0.00045	-2%
MA-3	0.00038	2%
Weighted MA-3	0.00038	1%
Exp Smoothing (.2)	0.00029	2%

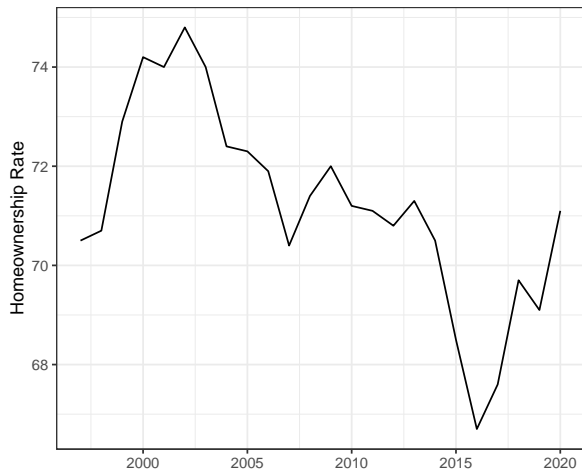
State	year	GDP_Rate	Naive	MA3	WMA3	ExpSmth
Missouri	1997	NA	NA	NA	NA	NA
Missouri	1998	0.04	NA	NA	NA	0.04
Missouri	1999	0.05	0.04	NA	NA	0.04
Missouri	2000	0.05	0.05	NA	NA	0.04
Missouri	2001	0.02	0.05	0.05	0.05	0.04
Missouri	2002	0.03	0.02	0.04	0.04	0.04
Missouri	2003	0.04	0.03	0.03	0.03	0.04

**To compare forecasts ONLY calculate the MSE on the rows with no missing data!**

e.g. starting at row 2001.

Forecast Tool	MSE	Prediction
Naive Forecast	0.00049	-2%
MA-3	0.00038	2%
Weighted MA-3	0.00038	1%
Exp Smoothing (.2)	0.00032	2%

# Assignment for Tuesday



What is the best forecast model of homeownership rates in MO?

- Naïve
- MA (3)
- Weighted MA (3), or
- Exponential Smoothing (0.2)

Predict 2021 and calculate the MSE!