Forecasting Intro

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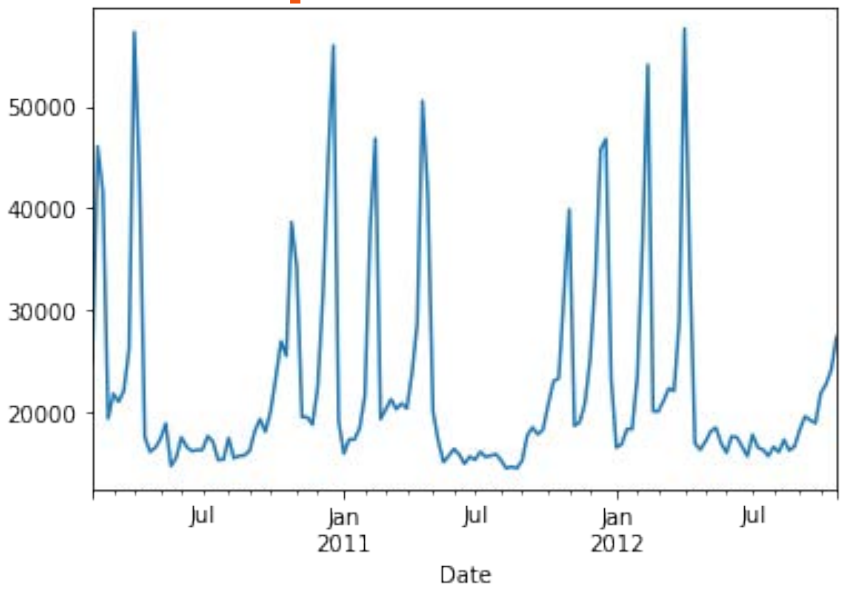
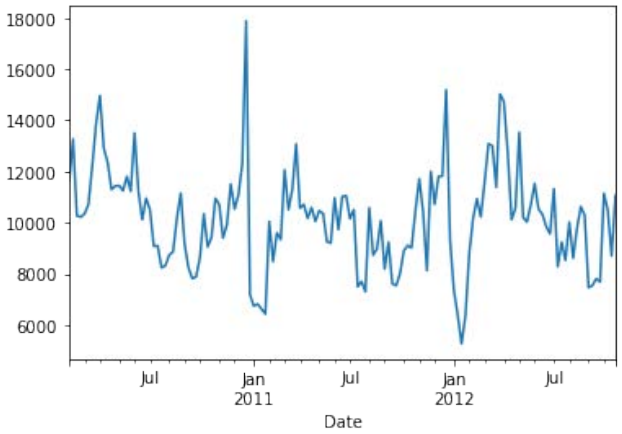
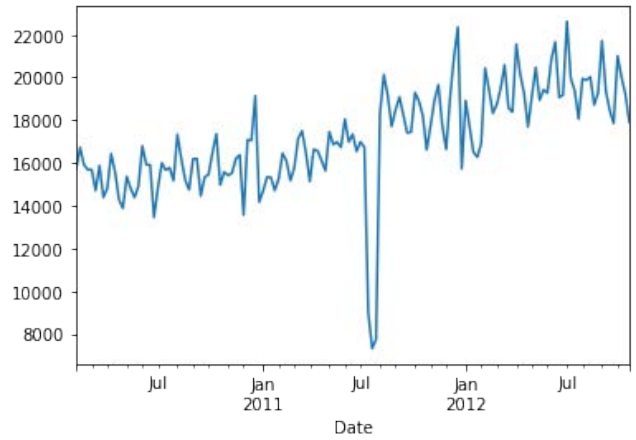
Patterns in Temporal Data

- Obtain
- Scrub
- Explore
- Model
- iNterpret







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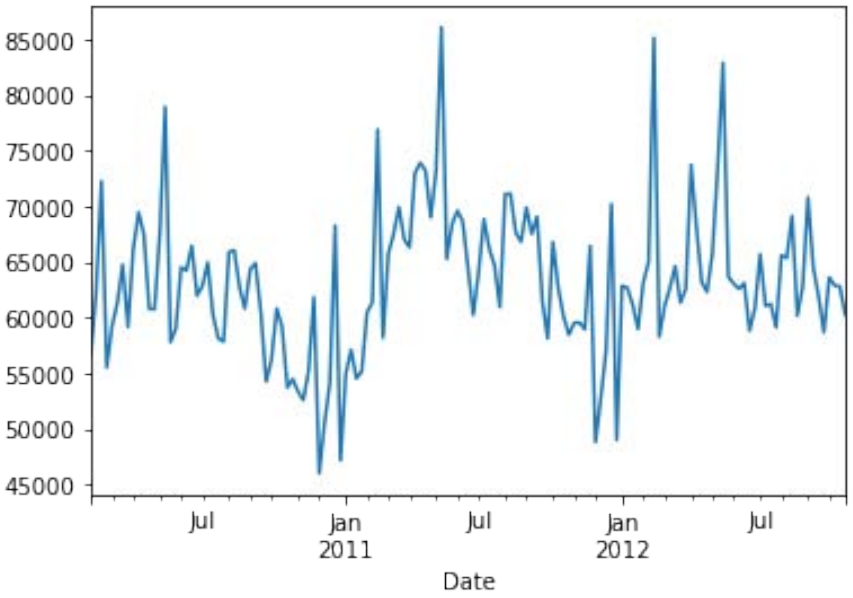
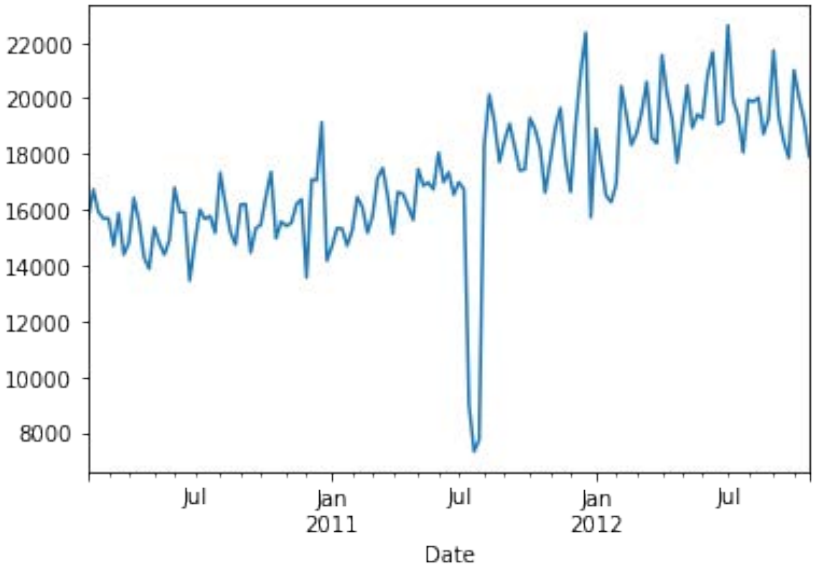
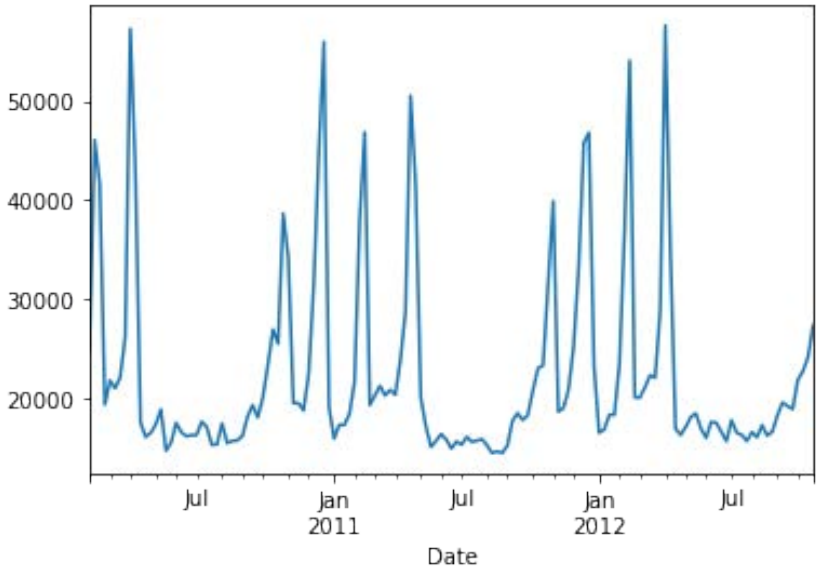
Our Challenge This Week?

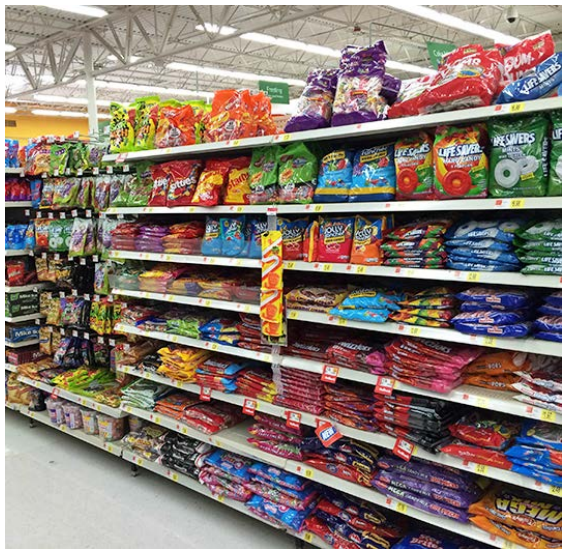


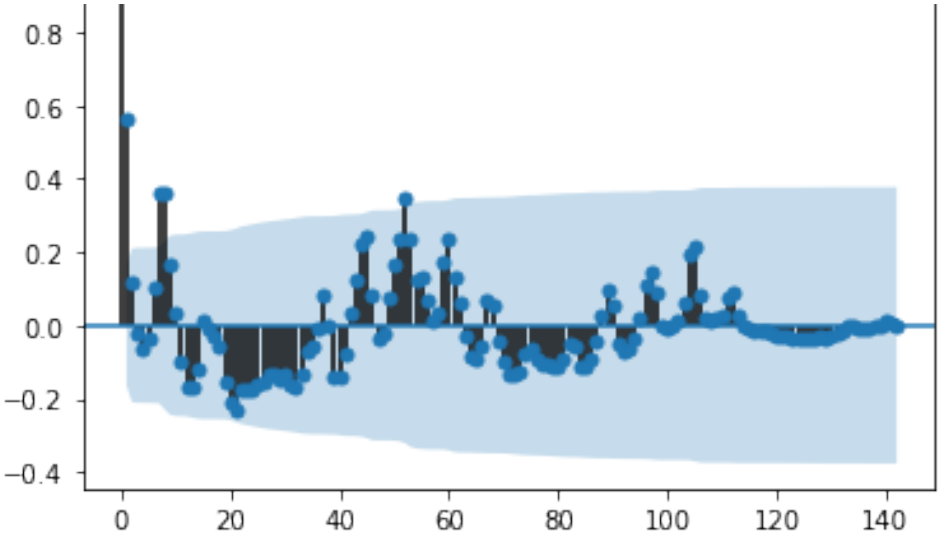
Will Sales Rise or Fall?

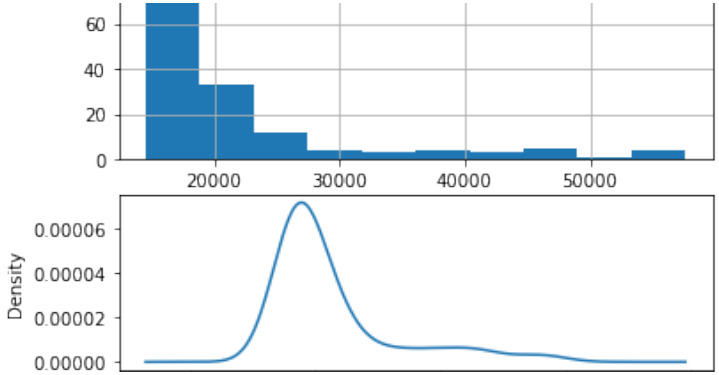




How Might We Know?







Date Review

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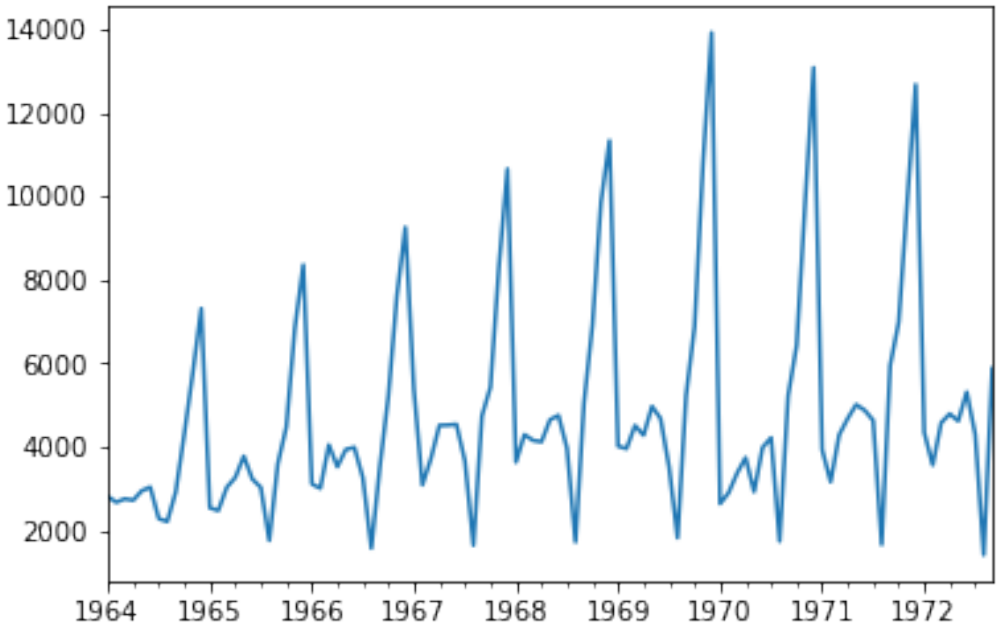
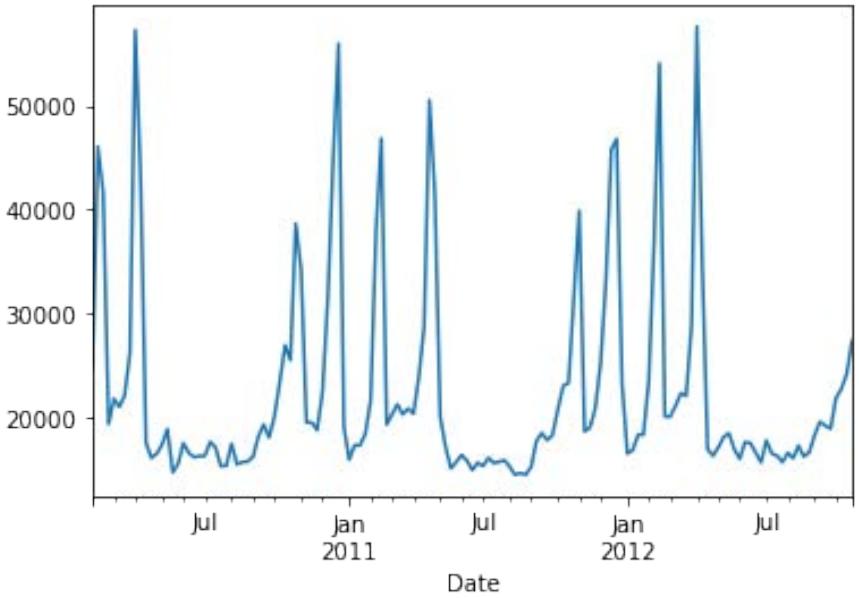
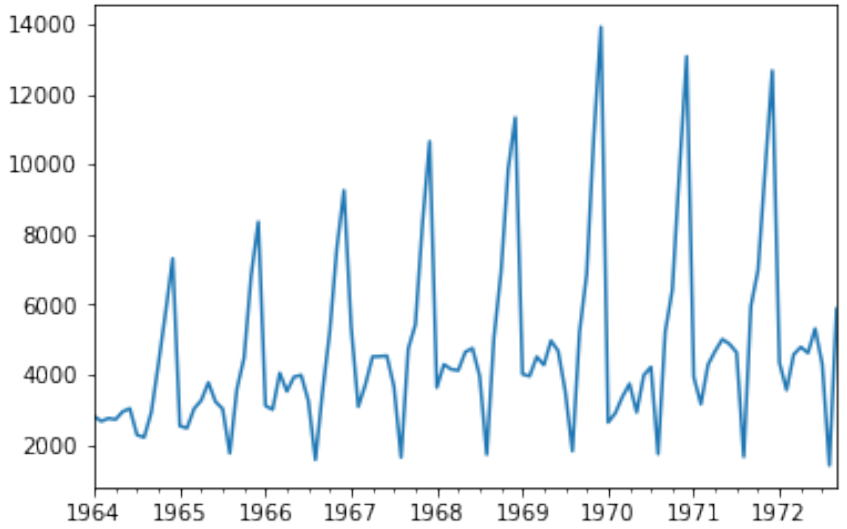
Temporal Data

1964-01	2815	1965-09	3595
1964-02	2672	1965-10	4474
1964-03	2755	1965-11	6838
1964-04	2721	1965-12	8357
1964-05	2946	1966-01	3113
1964-06	3036	1966-02	3006
1964-07	2282	1966-03	4047
1964-08	2212	1966-04	3523
1964-09	2922	1966-05	3937
1964-10	4301	1966-06	3986
1964-11	5764	1966-07	3260
1964-12	7312	1966-08	1573
1965-01	2541	1966-09	3528
1965-02	2475	1966-10	5211
1965-03	3031	1966-11	7614
1965-04	3266	1966-12	9254
1965-05	3776	1967-01	5375
1965-06	3230	1967-02	3088
1965-07	3028	1967-03	3718
1965-08	1759	1967-04	4514

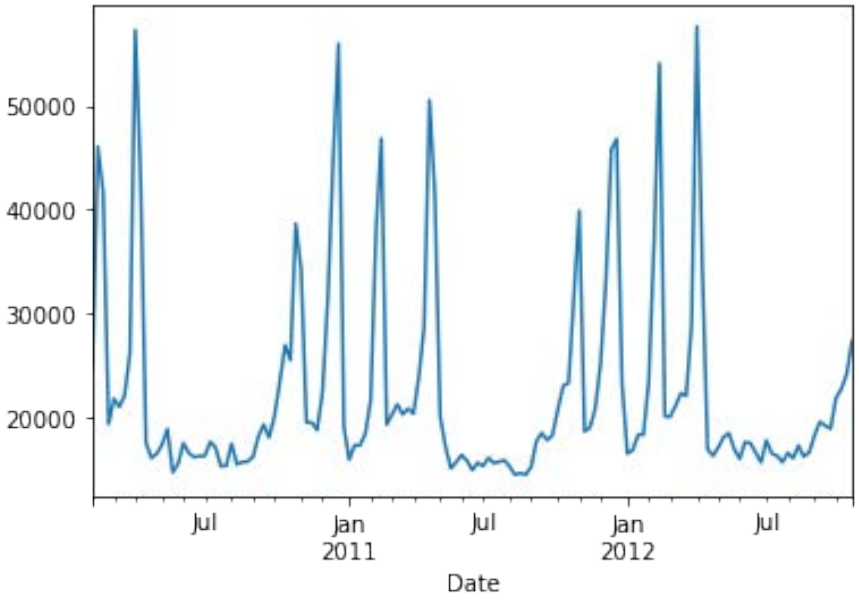


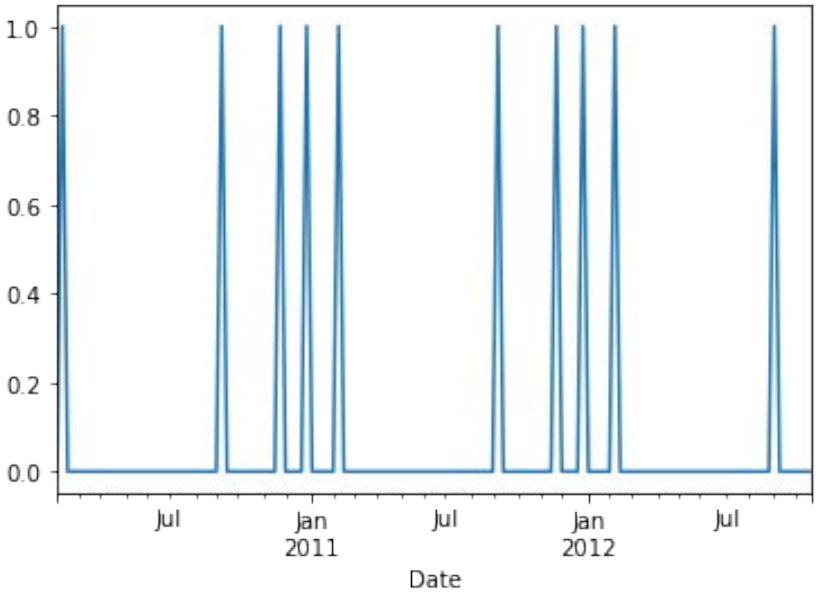
Seasonal Data



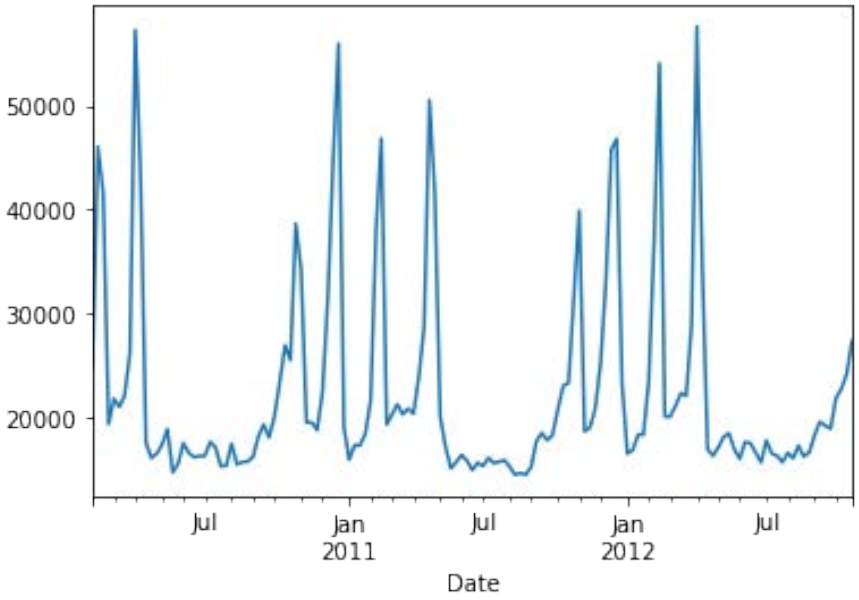


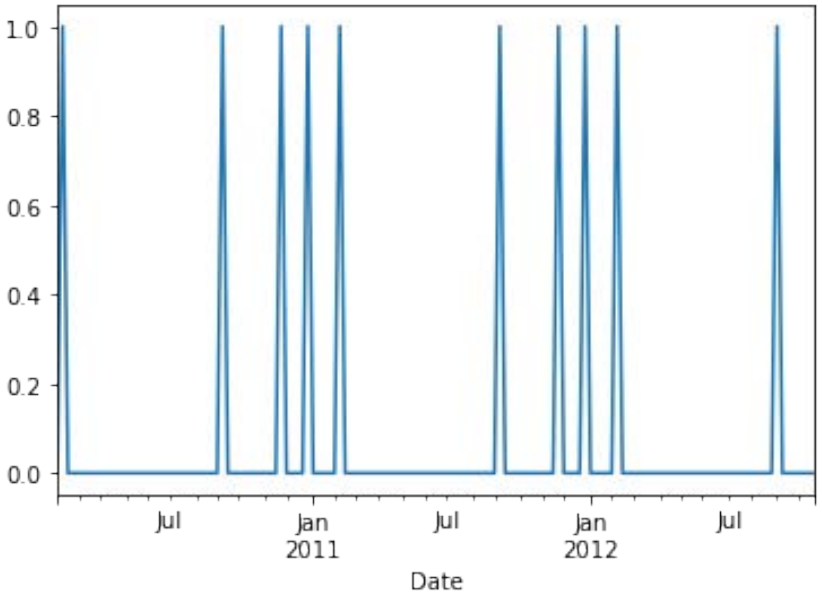
In Sample – Out of Sample



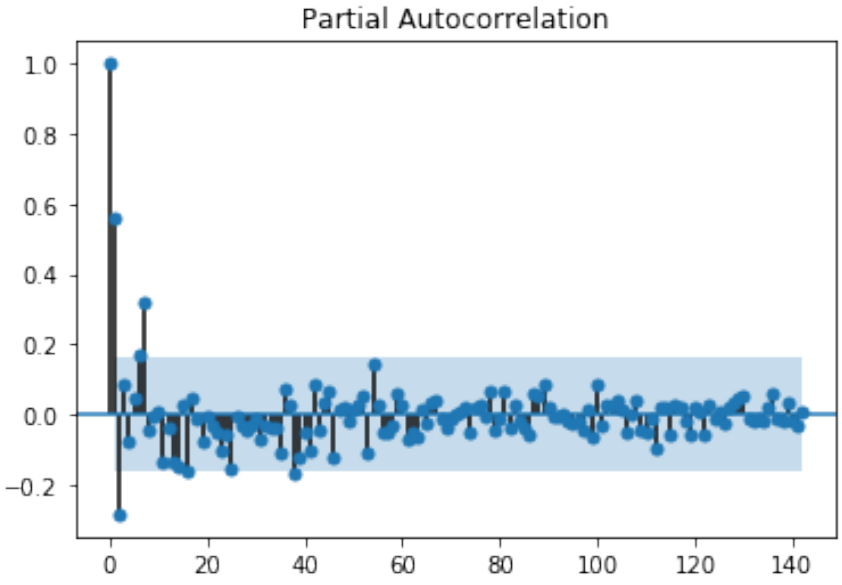


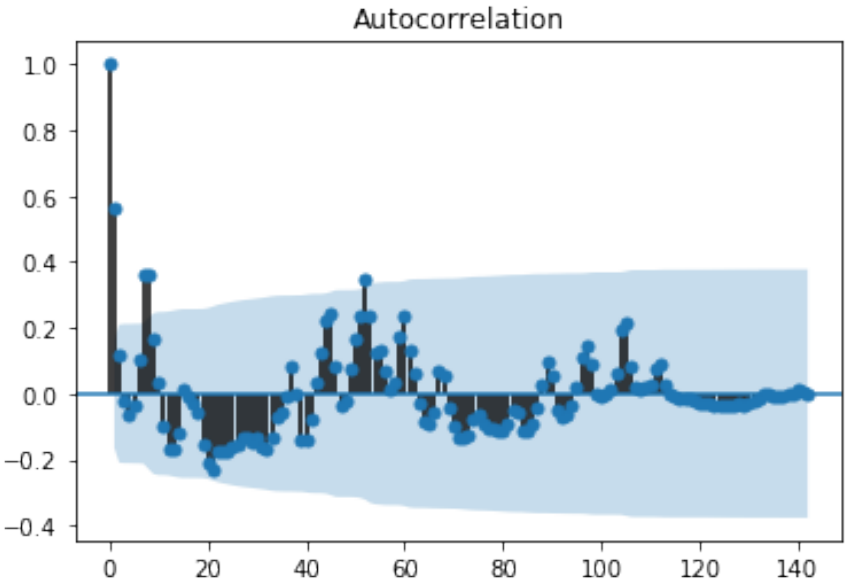
In Sample – Out of Sample (cont.)





Correlation





Recommendation

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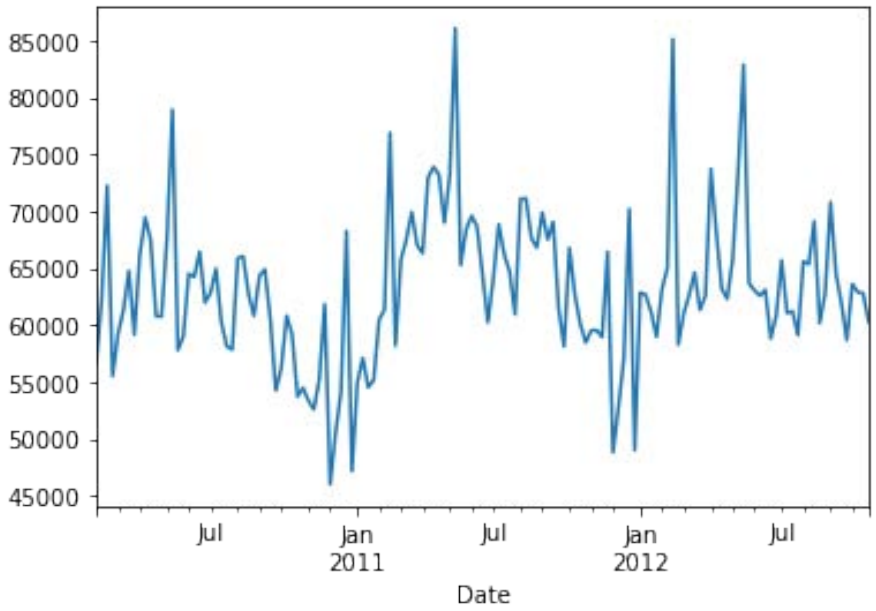
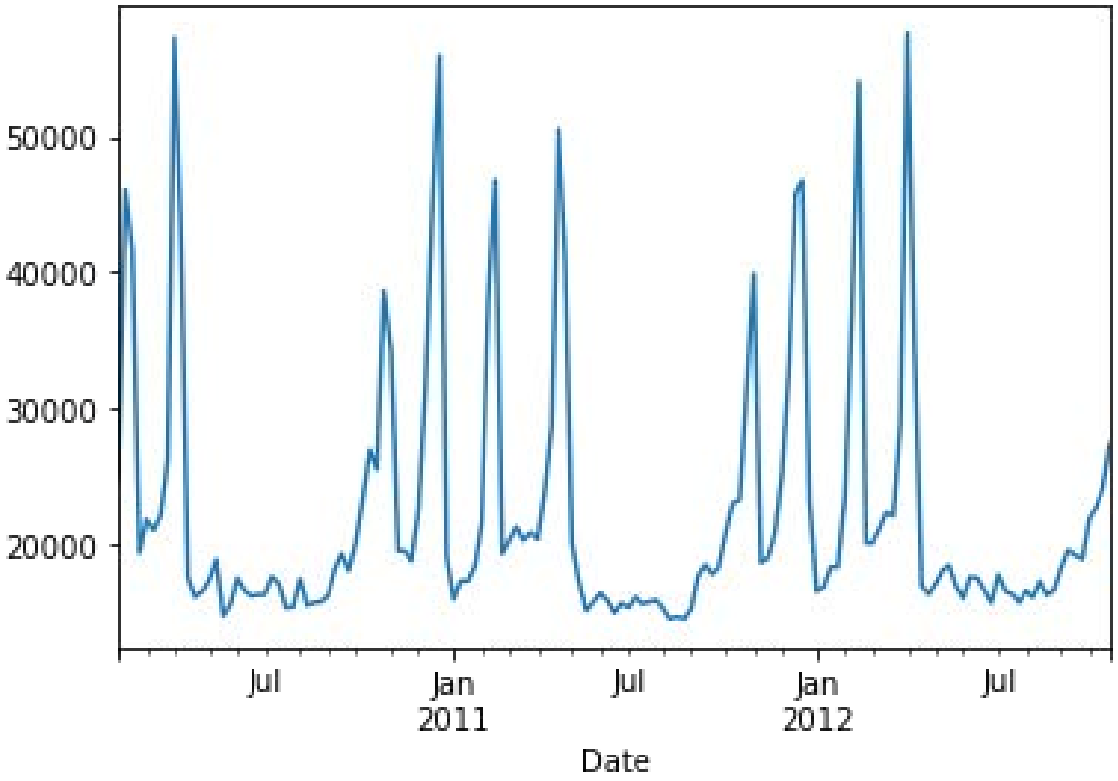
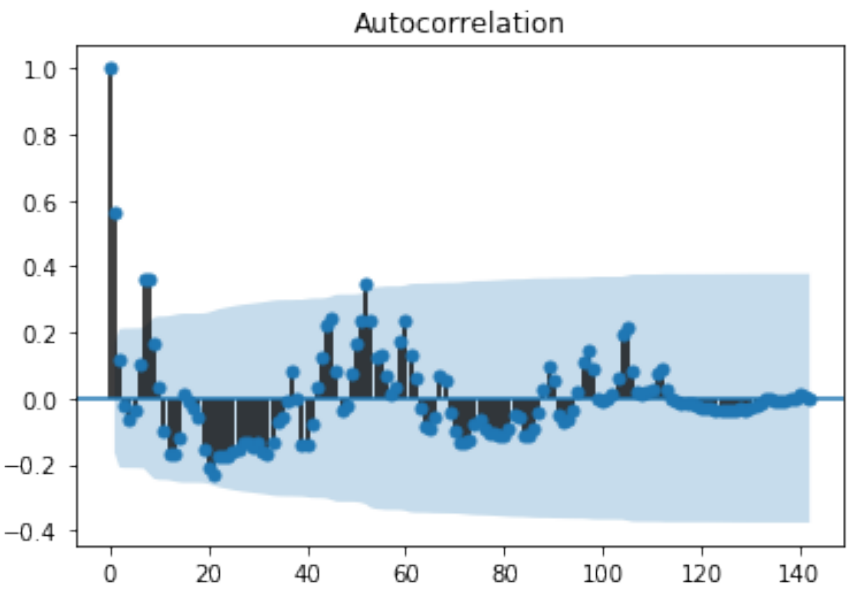
Our Challenge This Week?

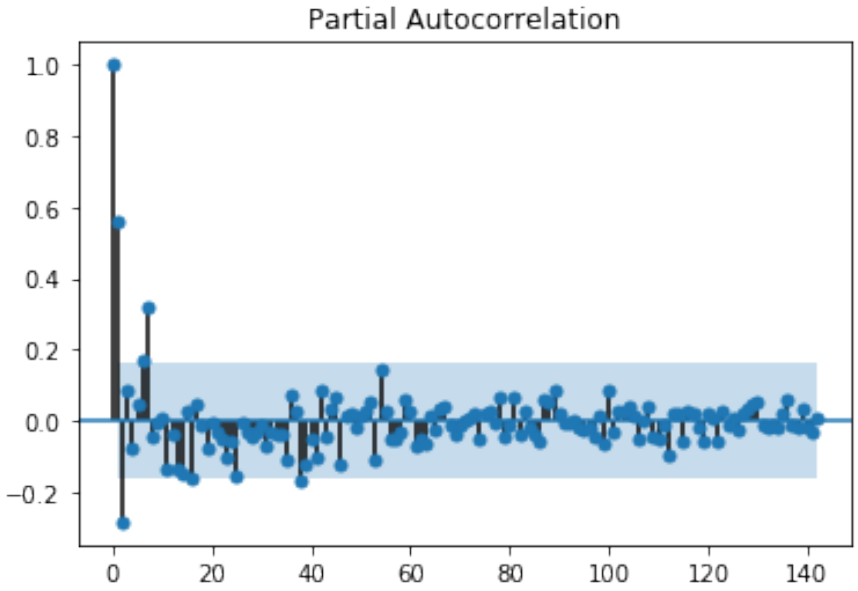


Will Sales Rise or Fall?



How Might We Know?





Stationary

ADF Statistic:

-8.892005

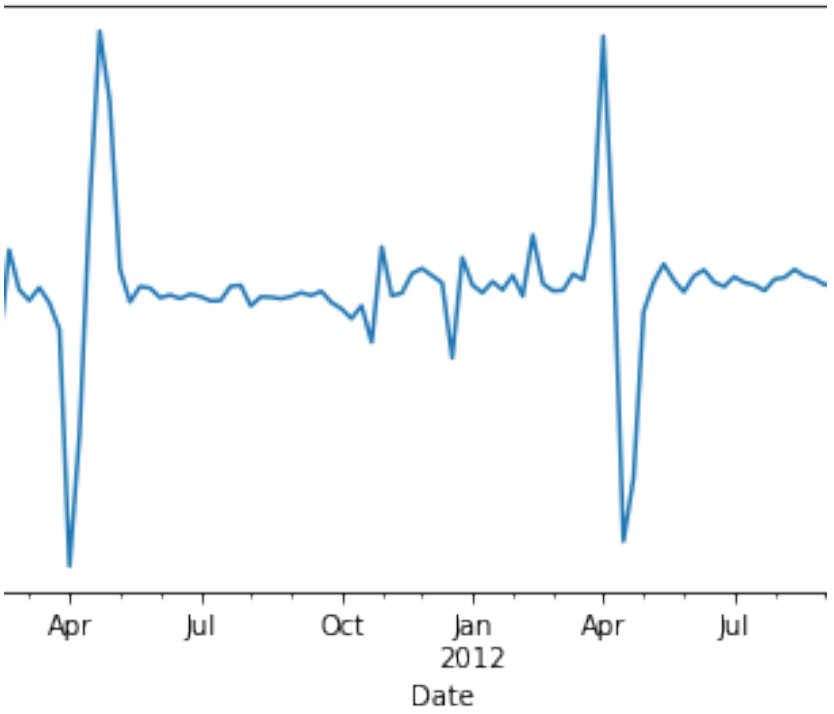
p-value: 0.000000

Critical Values:

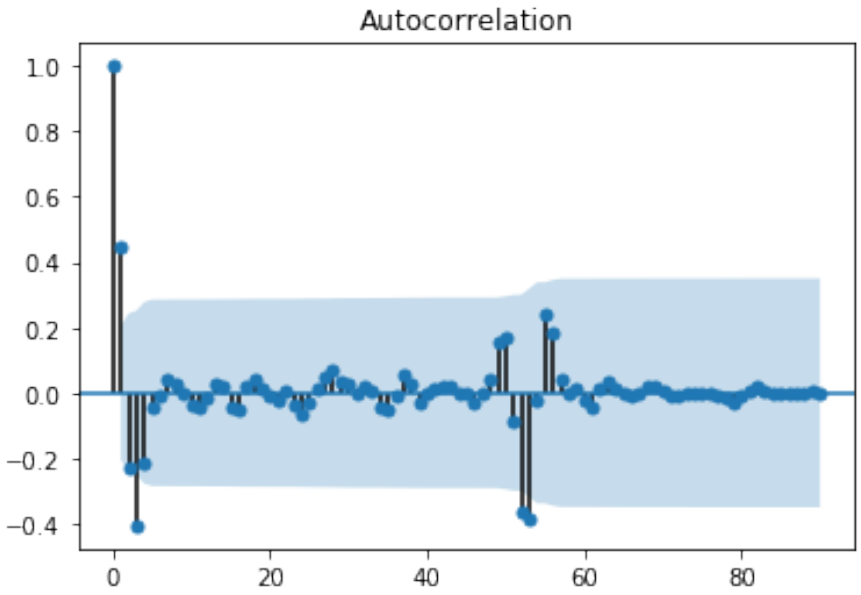
1%: -3.506

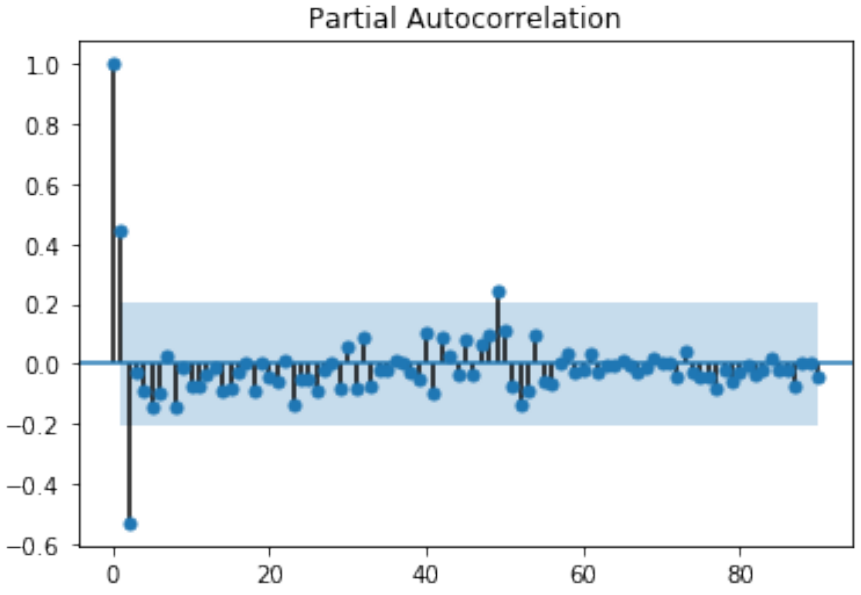
5%: -2.895

10%: -2.584



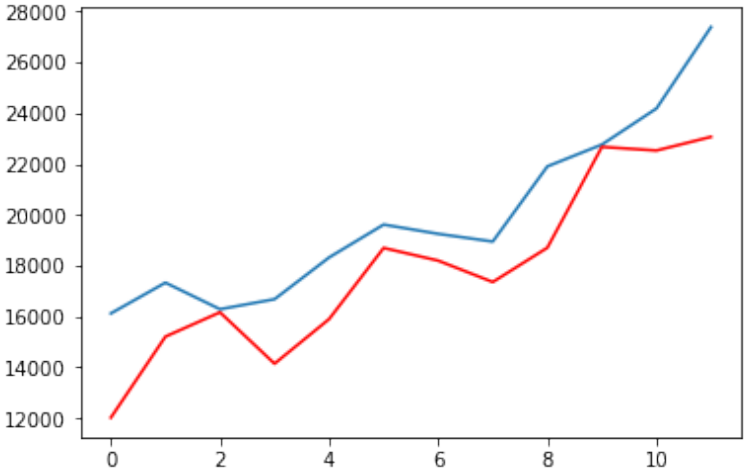
Modeling Input





Recommendation

- Increasing sales in next quarter
- Opportunity to close forecast gap
- Consider data transformations
- Consider methods to account for holiday



Forecasting

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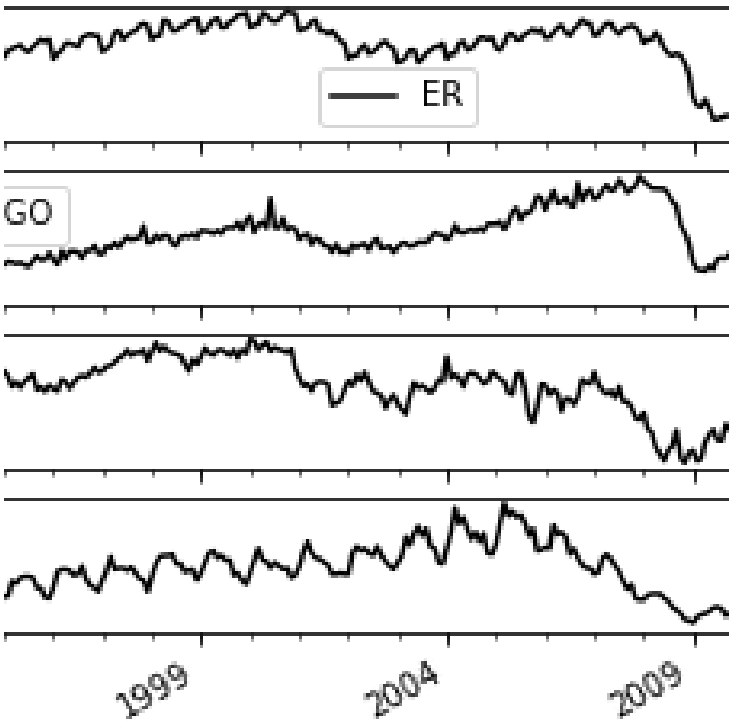
Patterns in Temporal Data

	10 Feb 2012 12:21	Missed Call	077	Hel
	10 Feb 2012 12:29	2 Seconds	077	Hel
	10 Feb 2012 13:47	1 Minute	0779	Hel
	10 Feb 2012 15:05	2 Minutes	019	
	10 Feb 2012 16:48	1 Minute	077	Hel
	10 Feb 2012 16:53	7 Seconds	077	Hel
	10 Feb 2012 16:54	39 Seconds	077	Hel
	10 Feb 2012 17:13	3 Seconds	077	Hel
	10 Feb 2012 17:13	2 Seconds	0779	Hel
	10 Feb 2012 17:14	2 Seconds	0779	Hel
	10 Feb 2012 17:16	2 Seconds	0779	Hel
	10 Feb 2012 17:20	2 Seconds	0779	Hel
	10 Feb 2012 17:23	2 Seconds	0779	Hel
	10 Feb 2012 17:25	10 Seconds	0779	Hel
	10 Feb 2012 20:07	11 Seconds	077	Hel
	11 Feb 2012 09:41	1 Minute	077	Hel
	12 Feb 2012 10:54	1 Minute	077	Hel
	13 Feb 2012 12:50	2 Minutes	077	Hel
	13 Feb 2012 14:52	38 Seconds	077	Hel
	14 Feb 2012 09:30	2 Minutes	0779	Hel
	14 Feb 2012 18:19	49 Seconds	0142	Orie
	15 Feb 2012 17:14	1 Minute	0779	Hel
	15 Feb 2012 17:18	Cancelled	0779	Hel
	15 Feb 2012 17:18	1 Minute	0779	Hel
	15 Feb 2012 17:26	Missed Call	0779	Hel
	15 Feb 2012 17:27	5 Seconds	0779	Hel

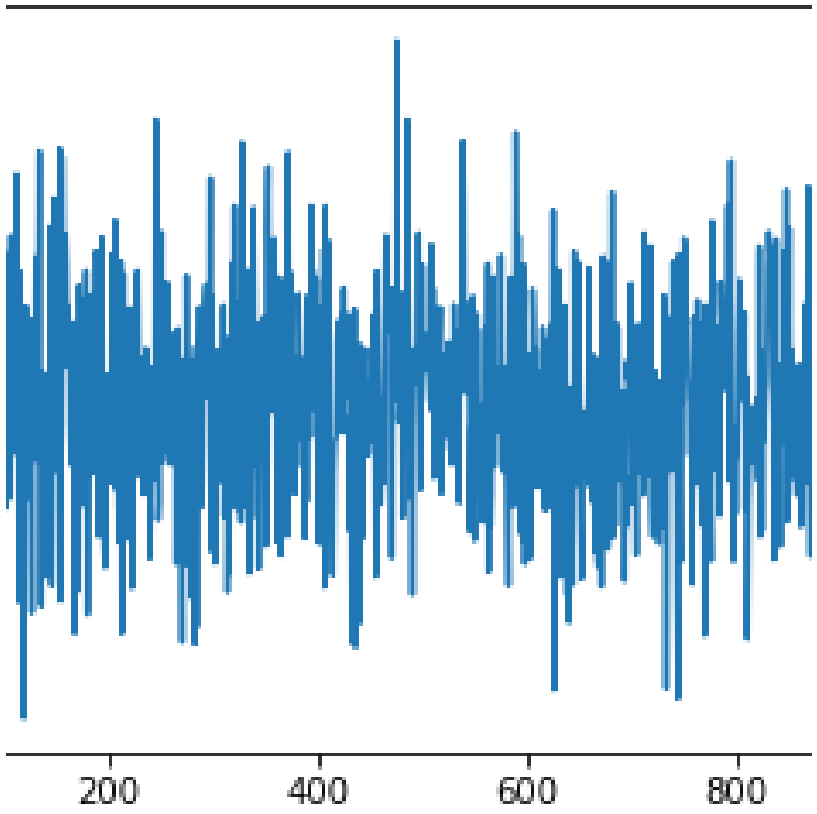
Forecasting

- White noise
- Covariance
- Seasonality
- Stationary

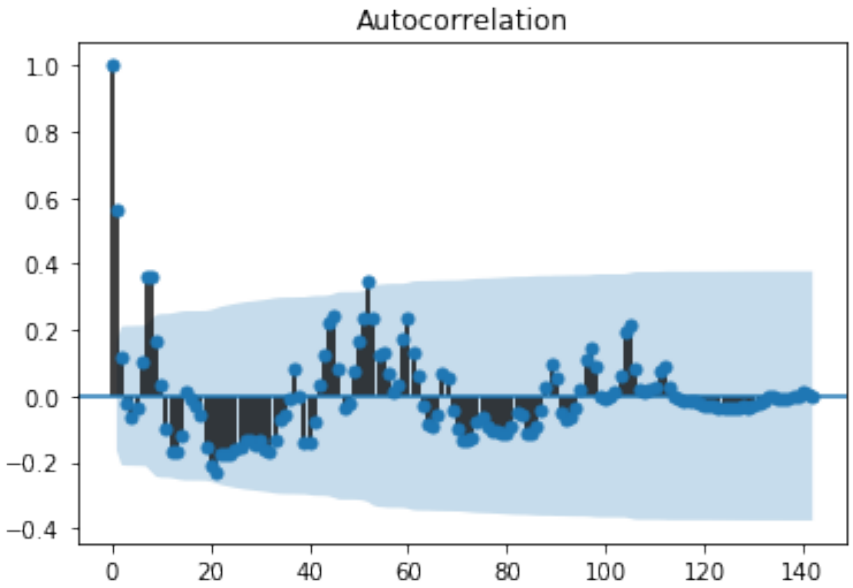


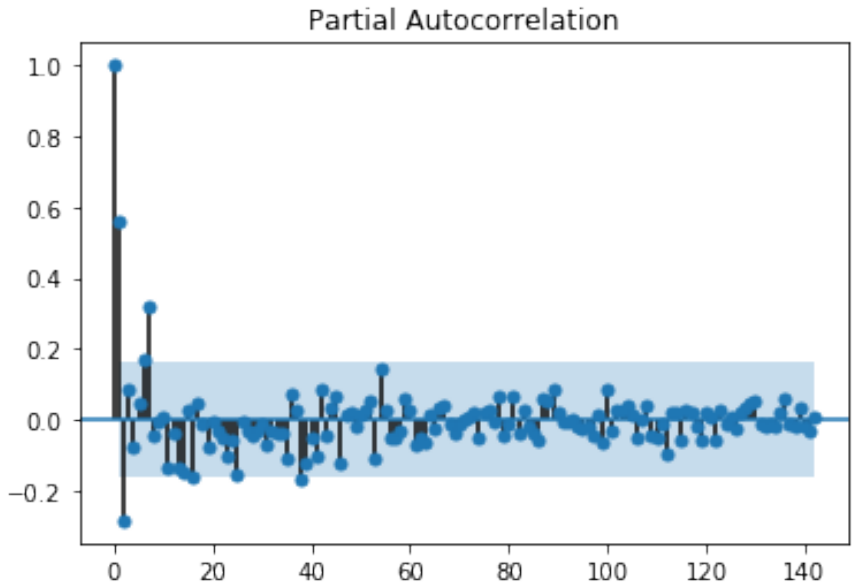
White Noise

- A random process
- Independent
- Identically distributed
- Mean = zero
- Variance = σ^2
- Correlation = zero



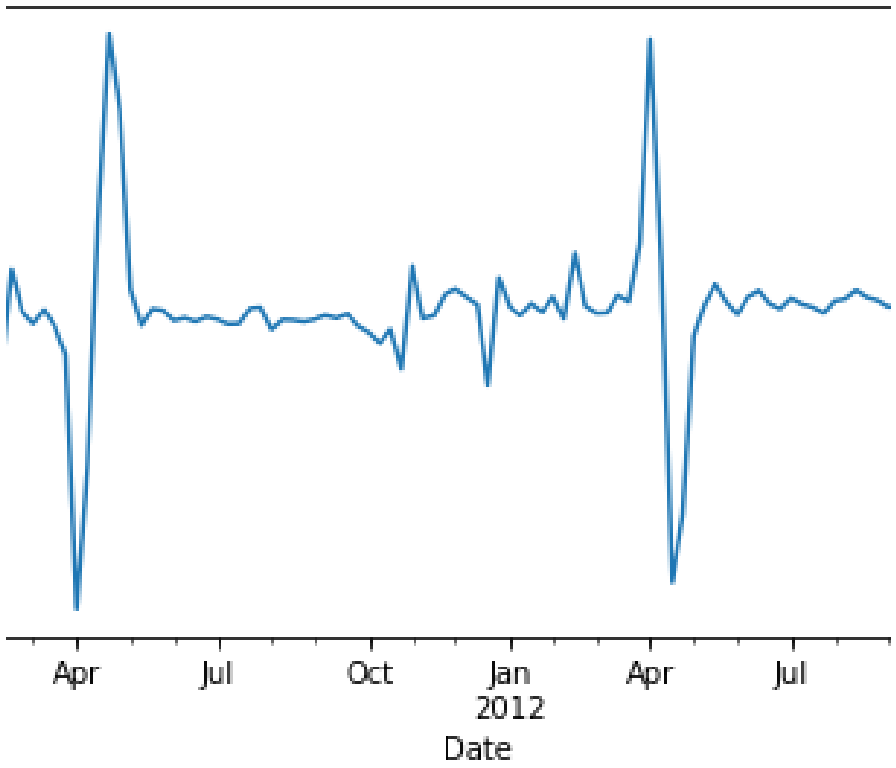
Covariance


Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
0
20
40
60
80
100
120
140

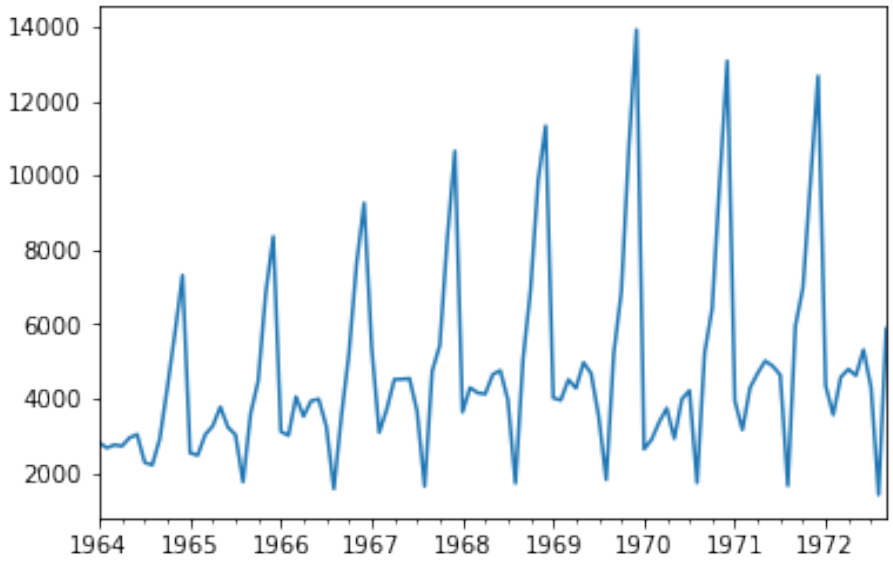

Partial Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
0
20
40
60
80
100
120
140

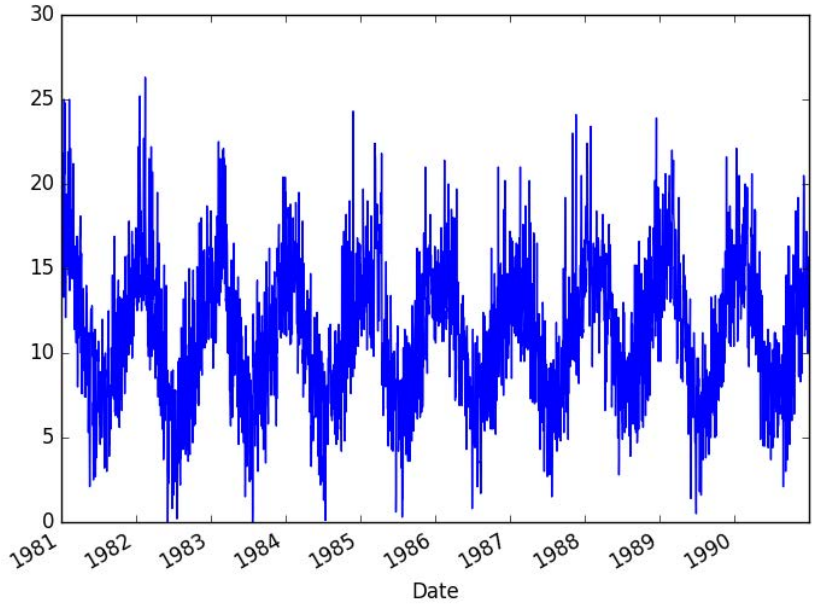
Stationary

- Process does not vary
- Mean stable over time
- Variance stable over time
- White noise?
  - Yes
- Seasonality?
  - No



Seasonality





ARIMA

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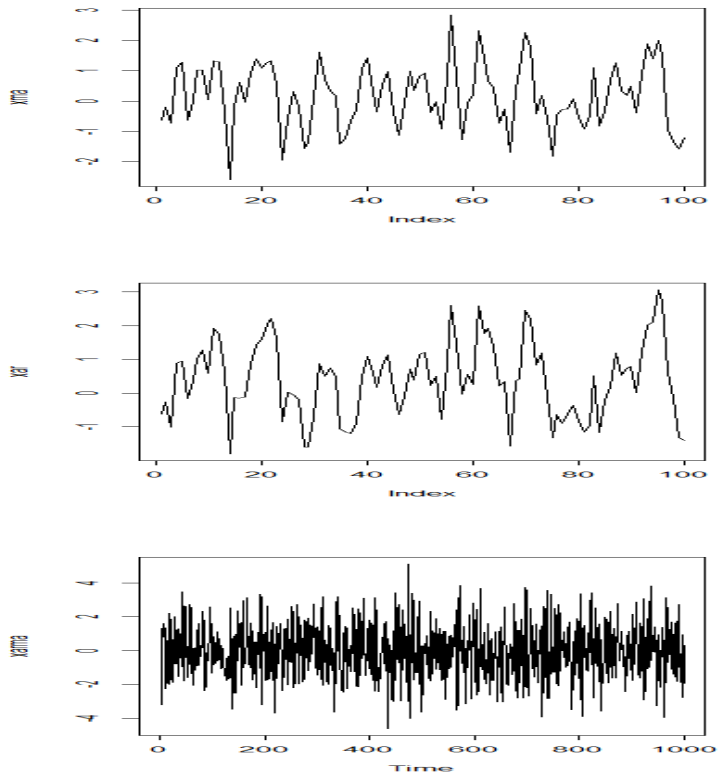
Dynamics of a Time Series

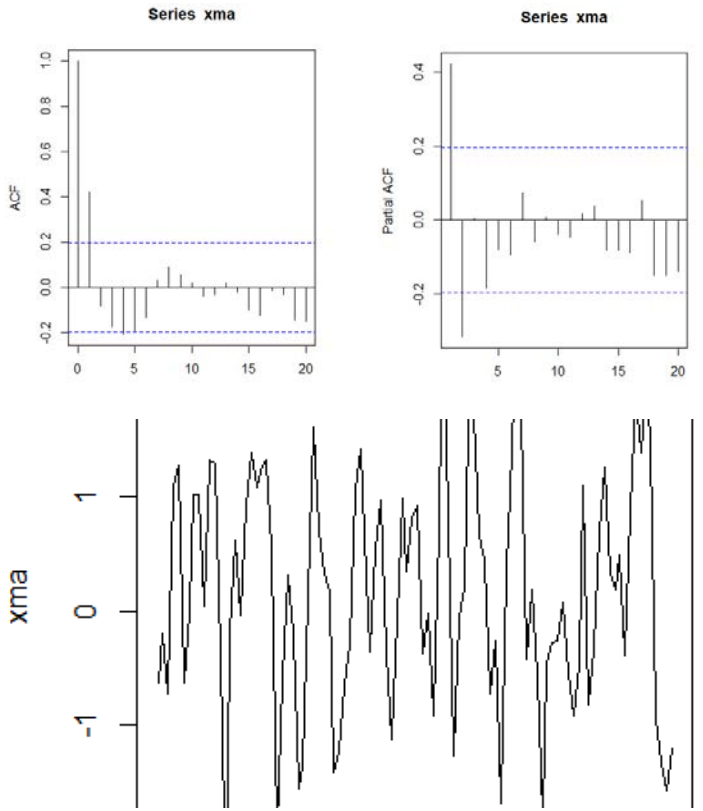
- Moving Average
- Autoregressive
- ARMA



Moving Average Process

$$Y_t = \mu + \varepsilon_t + \theta\varepsilon_{t-1}$$

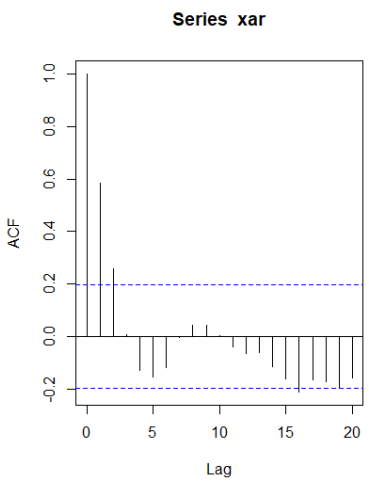
- Weighted sum of most recent
- ACF – contains spikes with rest zero
- Covariance stationary
  - Mean and autocovariance are not functions of time

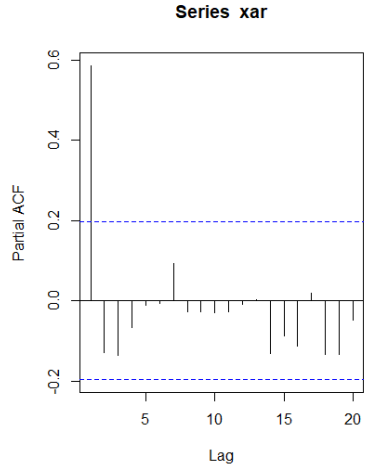


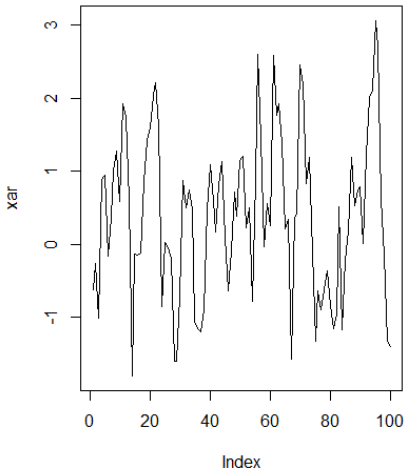
Autoregressive Process

$$Y_t = c + \varphi Y_{t-1} + \varepsilon_t$$

- Dependent on previous values
- ACF – decay to zero
- PACF – identify order at decay
- Stationary?



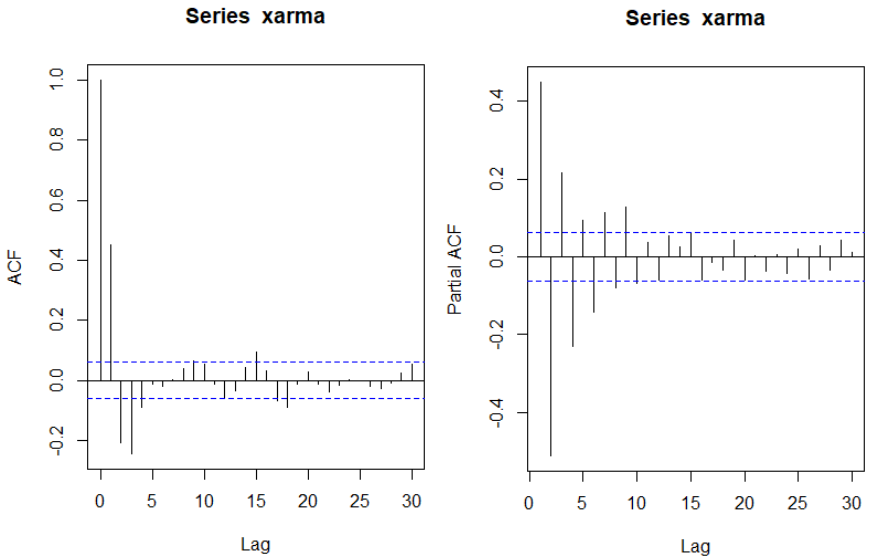


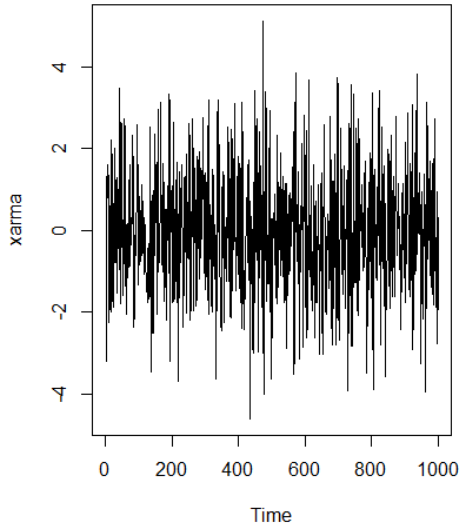


Arma/Arima

$$Y_t = c + \varphi Y_{t-1} + \varepsilon_t + \theta \varepsilon_{t-1}$$

- Mixture of AR and MA processes
- ACF – decay after lags
- PACF – identify order at decay





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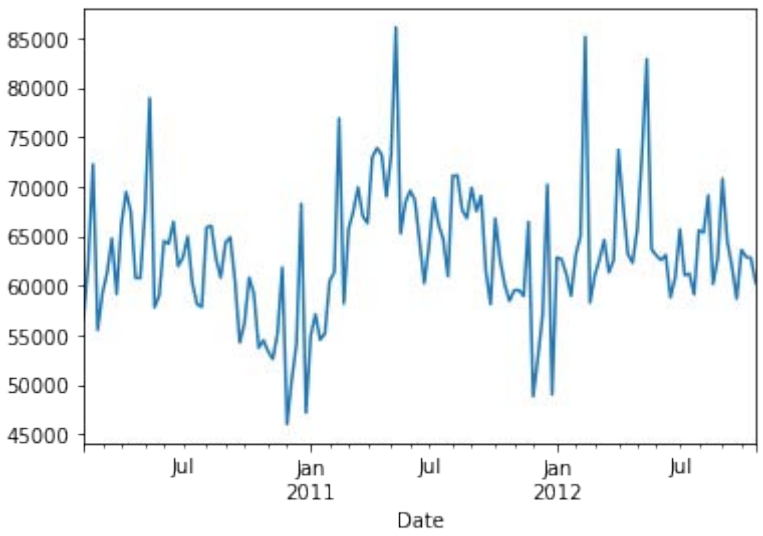
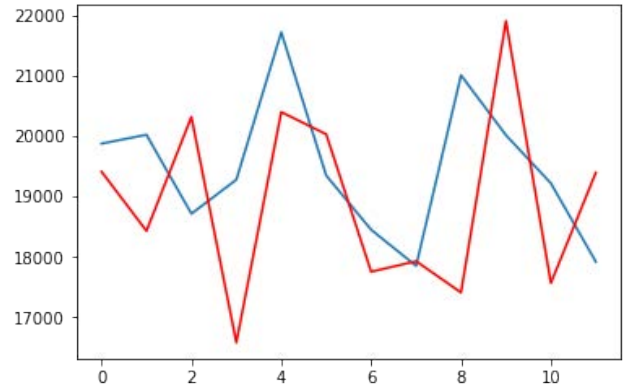
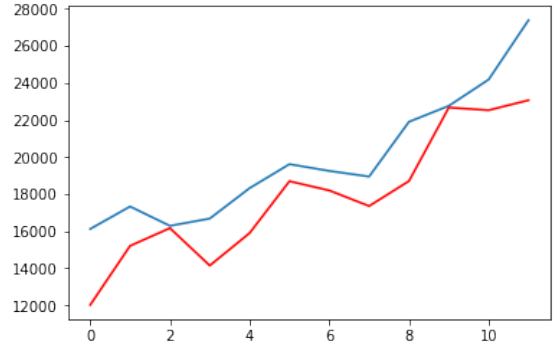
Our Challenge This Week?



Forecasting

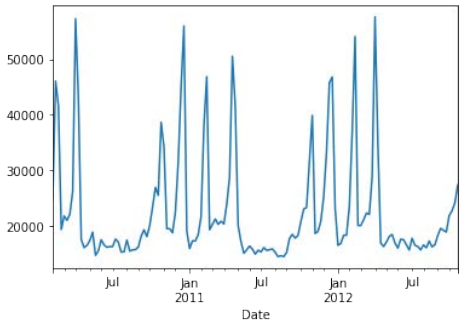
- Moving average smoothing
- Exponential smoothing
- Box Jenkins models

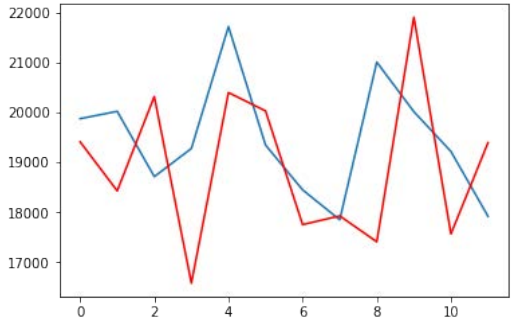




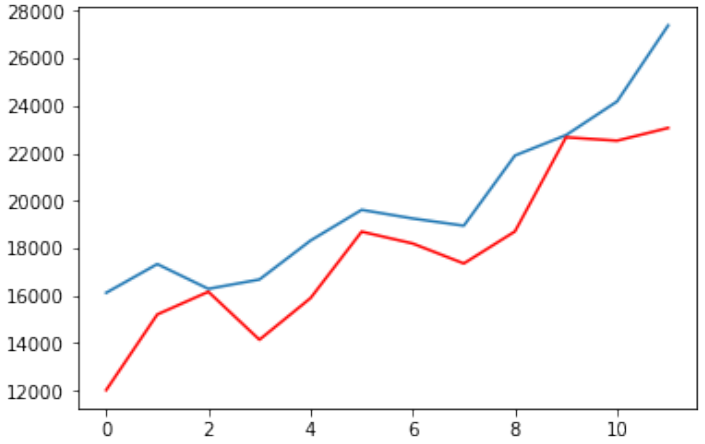
Box Jenkins or ARIMA Models

$$Y_t = c + \varphi Y_{t-1} + \varepsilon_t + \theta \varepsilon_{t-1}$$



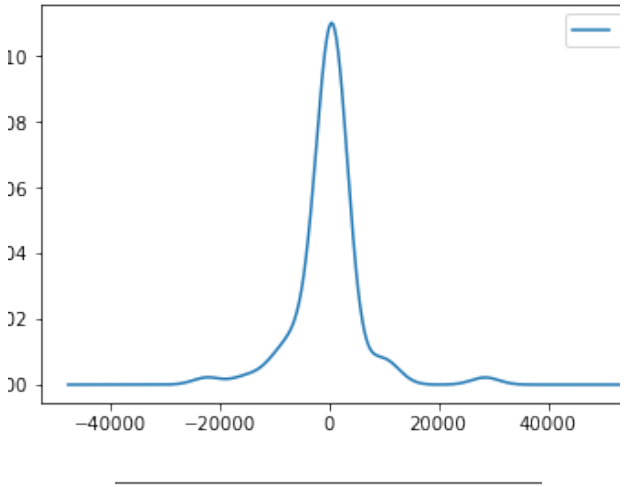


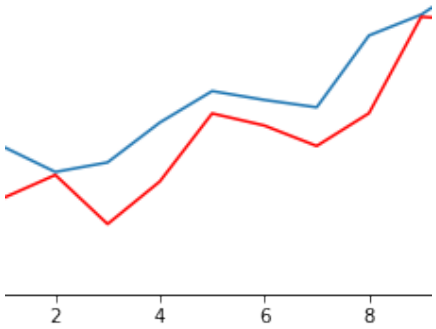
- Assumes stationary
- Transformation can help
- Model identification
- Model estimation
- Model validation



Model Validation

- Residual plot
- ACF – should decay to zero
- Root mean square error
  - mse = mean_squared_error(y, predictions)
  - rmse = sqrt(mse)





Data Structure

School of Information Studies
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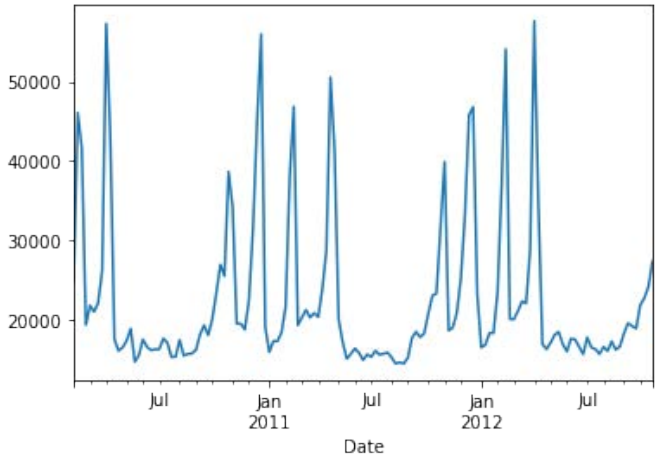
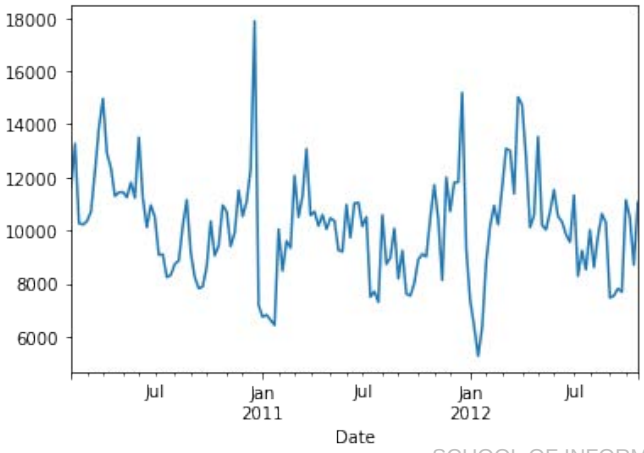
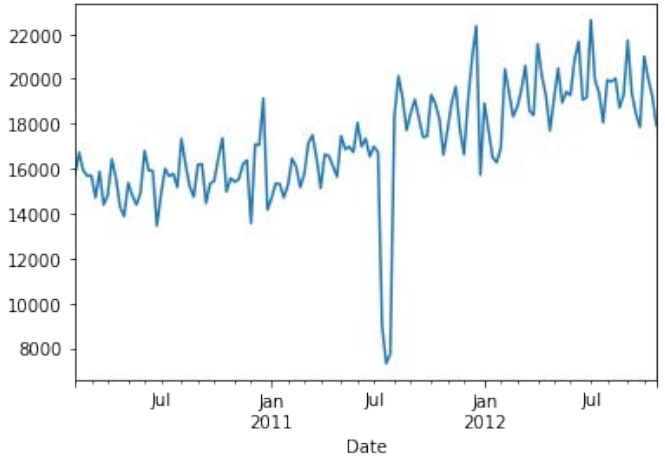
Temporal Data Structure

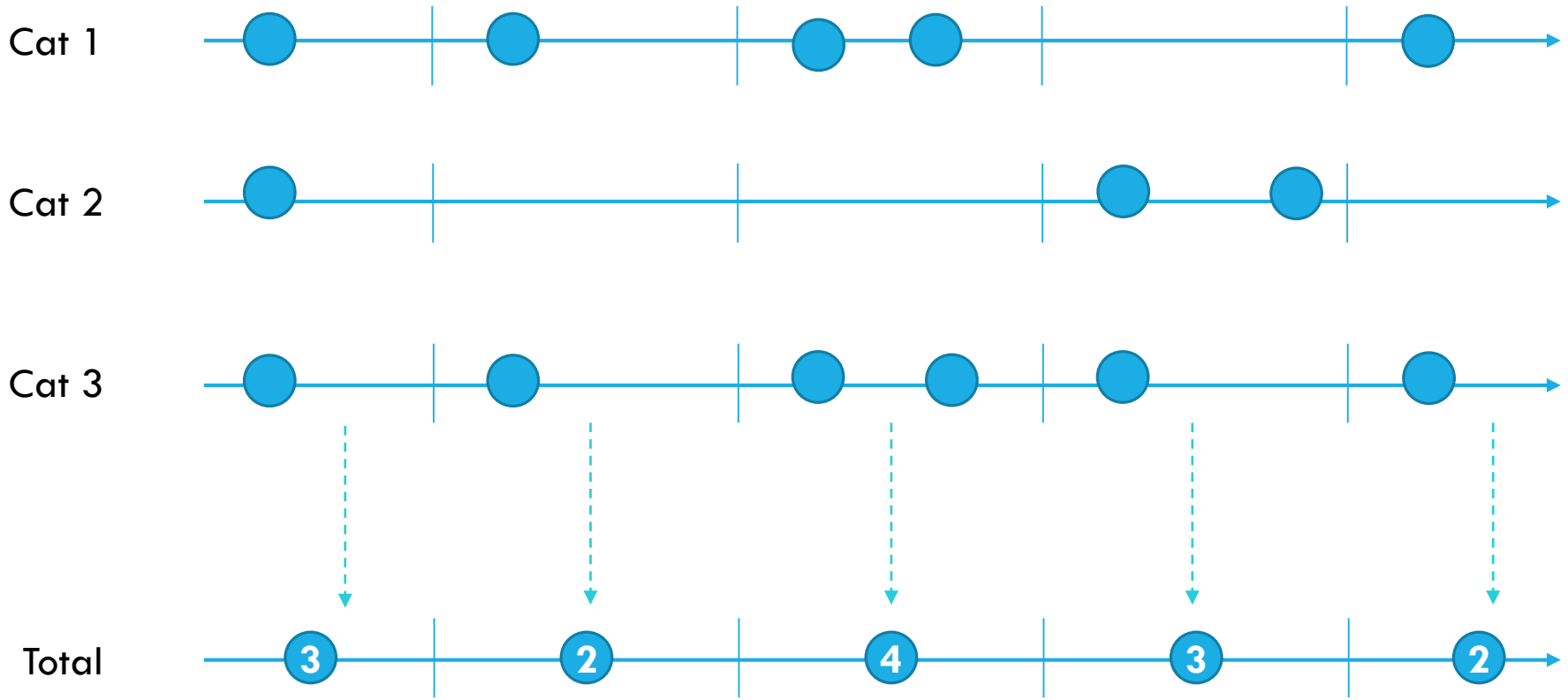
- Exploratory data analysis
- Temporal aggregation
- New features
- Transformation







Temporal Aggregation



New Features

- Function of the data
- Cumulative sums
- Frequencies
- Counts

- NOTE: Always perform causal modeling – never use future information to predict now

Transformations

- Normalize
  - Subtracting mean
  - Dividing maximum value
- Take the log
- Make categorical – bucketize
- Define threshold and make binary
  - >= threshold? 1
  - < threshold? 0