ISA 444: Business Forecasting

18 - ARMA Models

Fadel M. Megahed

Associate Professor
Department of Information Systems and Analytics
Farmer School of Business
Miami University
Email: fmegahed@miamioh.edu
Office Hours: Click here to schedule an appointment

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Outline

Recap of What we Have Covered Last Class [1]

ARMA Models: Models we considered may have two components, an autoregressive component (AR) and a moving average component (MA).

Main Learning Outcomes from Last Class

- **Describe the behavior of the ACF and PACF of an AR(p) process.**
- **Describe the behavior of the ACF and PACF of an MA(q) process.**

Recap of What we Have Covered Last Class [2]

Model	**ACF**	**PACF**
AR(p)	Exponentially decays or damped sinusoidal pattern	Cuts off after lag p
MA(q)	Cuts off after lag q	Exponentially decays or damped sinusoidal pattern

Non-Graded Class Activity [15 minutes]

For the file titled: 18 - inclass ARMA Practice.csv, please identify: (a) whether Series 1-6 can be modeled using an AR or MA model, and (b) the corresponding order for such a model.

Learning Outcomes for Today's Class

Main Learning Outcomes

- **Describe the behavior of the ACF and PACF of an ARMA (p,q) process.**
- **Fit an ARMA model to a time series, evaluate the residuals of a fitted ARMA model to assess goodness of fit, use the Ljung-Box test for correlation among the residuals of an ARIMA model.**

Outline

Mixed Autoregressive Moving Average Processes [1]

Sometimes, if a really high order seems needed for an AR process, it may be better, instead, to add one or more MA term. This results in a mixed autoregressive moving average or an ARMA model.

In general, an ARMA(p,q) model is given as

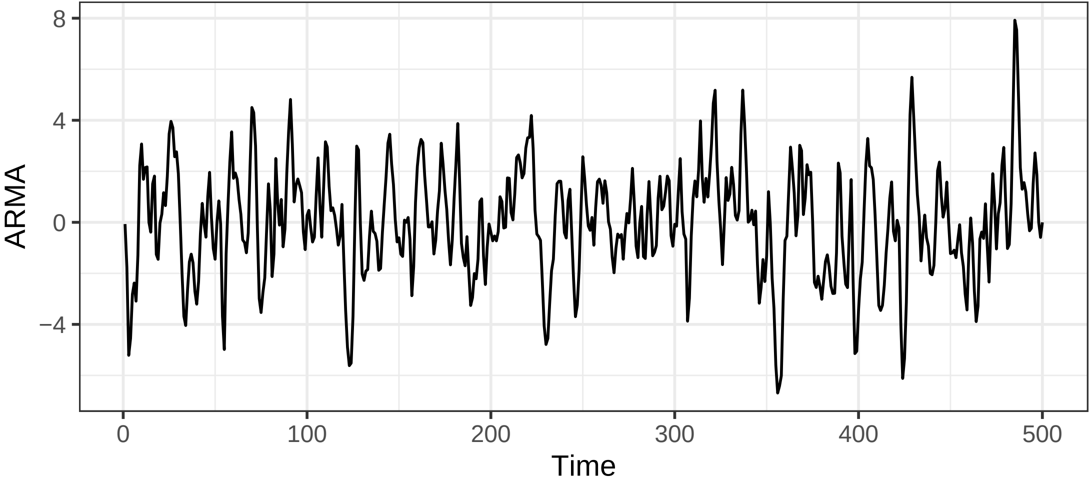
$$y_t = \delta + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \epsilon_t - \theta_1 \epsilon_{t-1} - \cdots - \theta_q \epsilon_{t-q}$$

The ACF and PACF of the ARMA(p,q) process exhibit exponential decay exponential decay and/or damped sinusoid patterns. This makes identification of the order of the ARMA(p,q) process difficult.

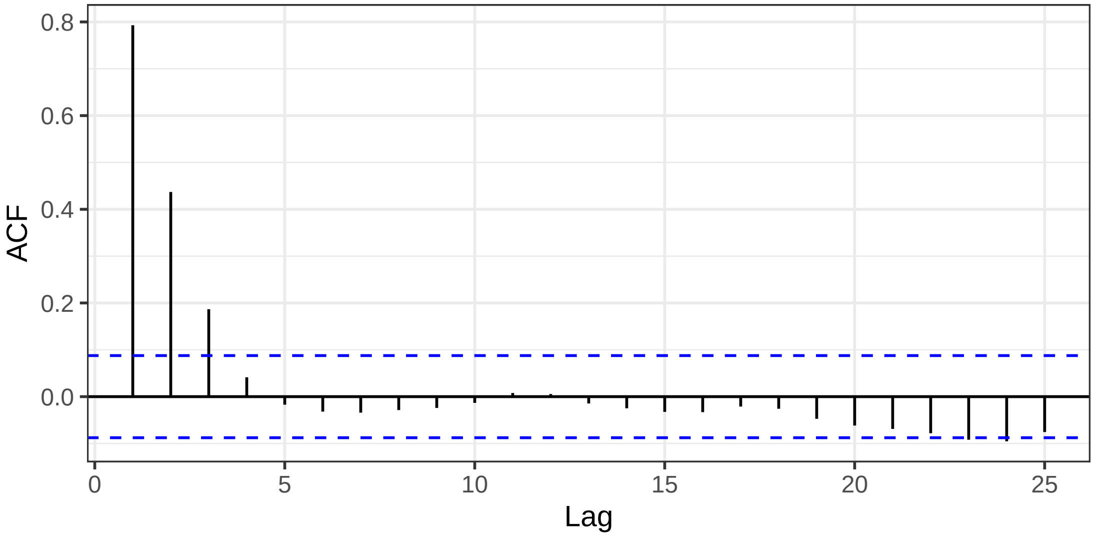
Mixed Autoregressive Moving Average Processes [2]

Model	ACF	PACF
AR(p)	Exponentially decays or damped sinusoidal pattern	Cuts off after lag p
MA(q)	Cuts off after lag q	Exponentially decays or damped sinusoidal pattern
ARMA(p,q)	Exponentially decays or damped sinusoidal pattern	Exponentially decays or damped sinusoidal pattern

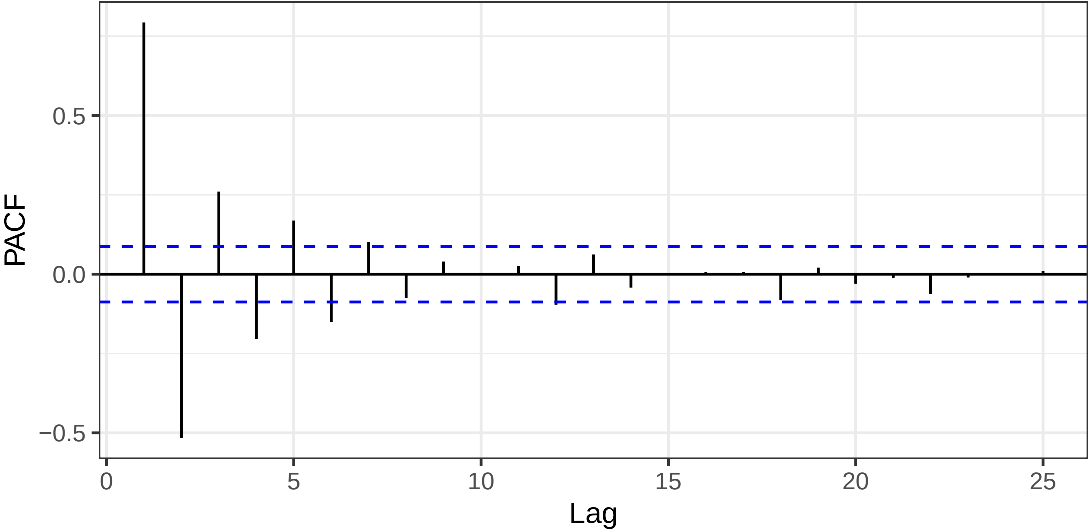
Example Plot of an ARMA(1,1): AR=.6, MA=.8 [1]



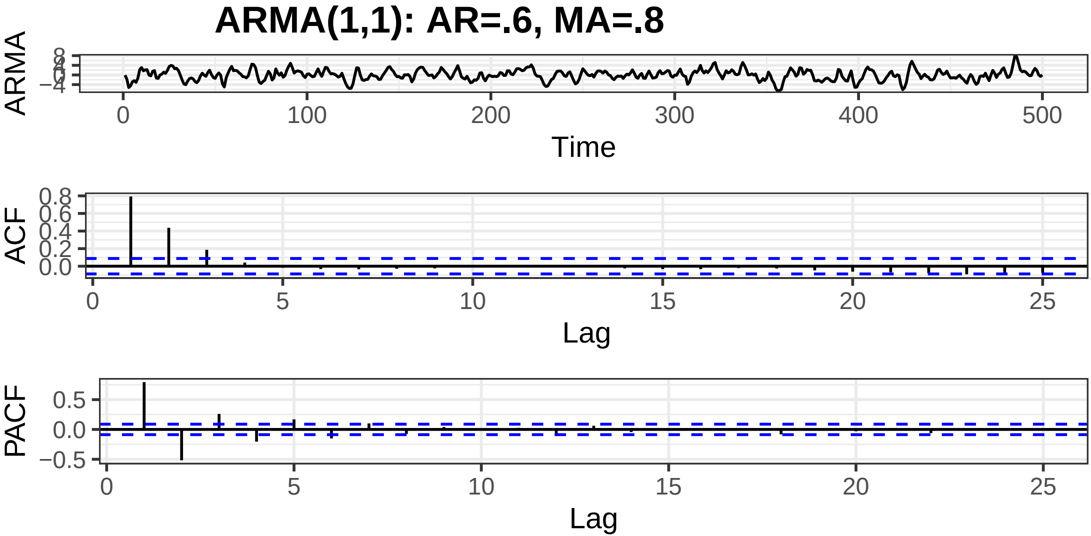
Example Plot of an ARMA(1,1): AR=.6, MA=.8 [2]



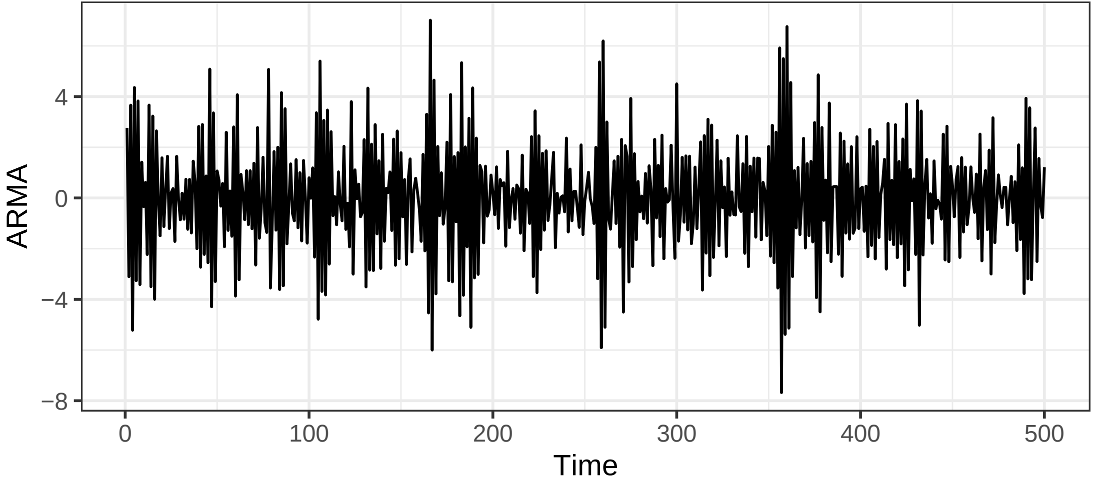
Example Plot of an ARMA(1,1): AR=.6, MA=.8 [3]



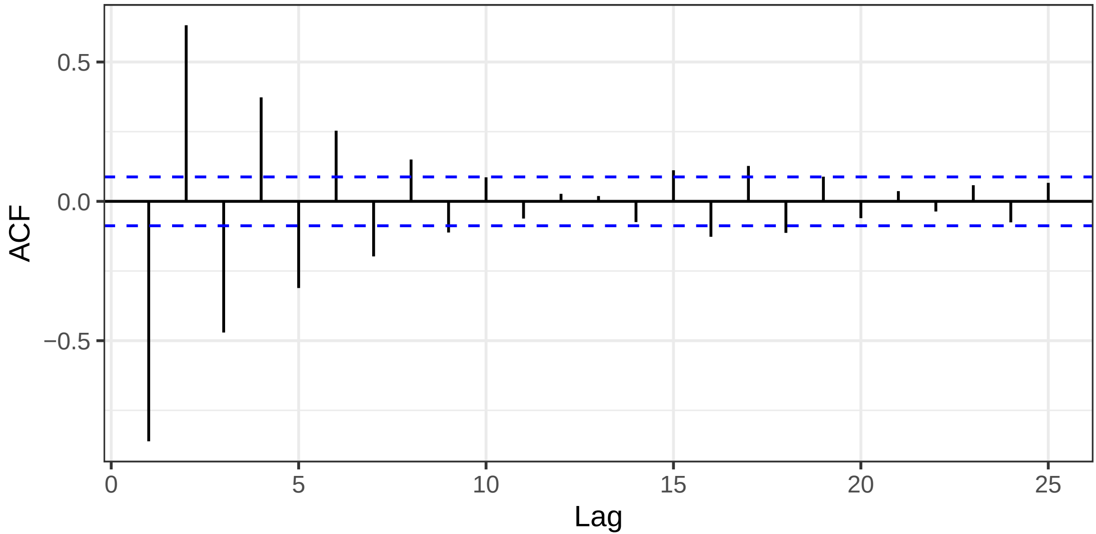
Example Plot of an ARMA(1,1): AR=.6, MA=.8 [4]



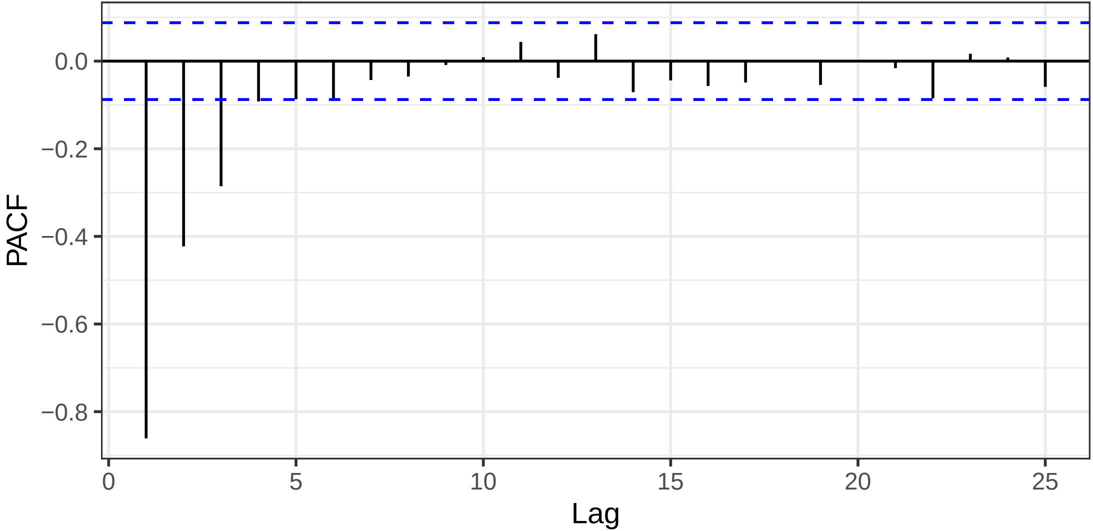
Example Plots of an ARMA(1,1): AR=-.7, MA=-.6 [1]



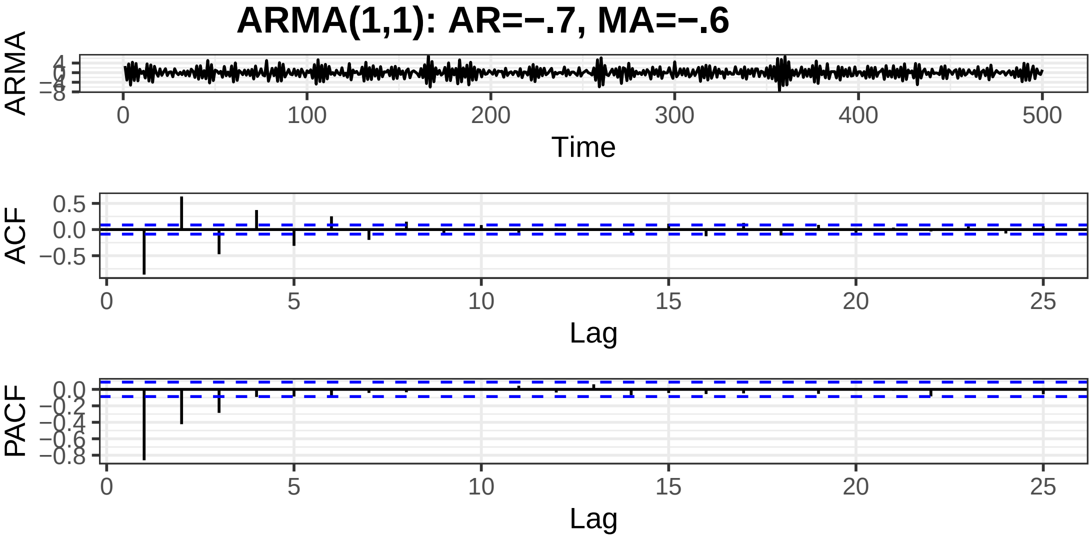
Example Plots of an ARMA(1,1): AR=-.7, MA=-.6 [2]



Example Plots of an ARMA(1,1): AR=-.7, MA=-.6 [3]



Example Plots of an ARMA(1,1): AR=-.7, MA=-.6 [4]



Outline

The 5-Step Procedure [1]

1. Plot the data over time.
2. Do the data seem stationary? If necessary, conduct a test for stationarity.
3. Once you can assume stationarity, find the ACF plot.
   a. If the ACF plot cuts off, fit an MA(q), where $q =$ the cutoff point.
   b. If the ACF plot dies down, find the PACF plot.
      i. If the PACF plot cuts off, fit an AR(p) model, where $p =$ the cutoff point.
      ii. If the PACF plot dies down, fit an ARMA (p, q) model.
      You must iterate through p and q using a guess and check method starting with ARMA(1,1) models – increment each by 1.
4. Evaluate the model residuals and consider the ACF and PACF of the residuals.
5. If model fit is good, forecast future values.

The 5-Step Procedure [2]

Note:

- Often you will fit multiple models in Step 3 and compare models in Step 4 to select the best fit.

Live Demo

Viscosity of a fluid is a measure that corresponds to “thickness”. For example, honey has a higher viscosity than water. A chemical company needs precise forecasts of the viscosity of a product in order to control product quality. Using the 18 - viscosity.csv, we have 95 daily readings to use to develop a forecast. **In order to develop a forecast, let us first figure out what type of ARMA(p, q) model to fit and then develop the forecast.**

Outline

Summary Table

Model	**ACF**	**PACF**
AR(p)	Exponentially decays or damped sinusoidal pattern	Cuts off after lag p
MA(q)	Cuts off after lag q	Exponentially decays or damped sinusoidal pattern
ARMA(p,q)	Exponentially decays or damped sinusoidal pattern	Exponentially decays or damped sinusoidal pattern

Things to Do to Prepare for Next Class

- Thoroughly read Chapters 6.2.1 - 6.2.4 of our textbook.
- Go through the slides, examples and make sure you have a good understanding of what we have covered.
- **Practice:** For the file titled: 18 - inclass ARMA Practice.csv, please identify: (a) whether Series 1-10, fit the appropriate ARMA(p, q) model and use the `checkresiduals()` to ensure that your residuals are uncorrelated.

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