

# **CSSS/POLS 512 - Time Series and Panel Data Methods**

## **Lab 4: Modeling Non-Stationary Time Series**

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# Preview

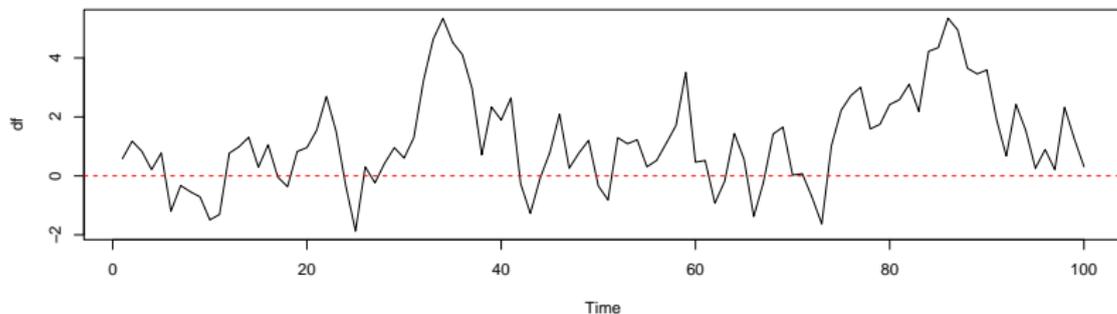
- ▶ Review of Problem Set 1
- ▶ Non-Stationary Time Series
  - ▶ ARIMA( $p, d, q$ )
  - ▶ Unit Root Test
  - ▶ Counterfactual
- ▶ For your reference:
  - ▶ Cointegration

# Review of Problem Set 1

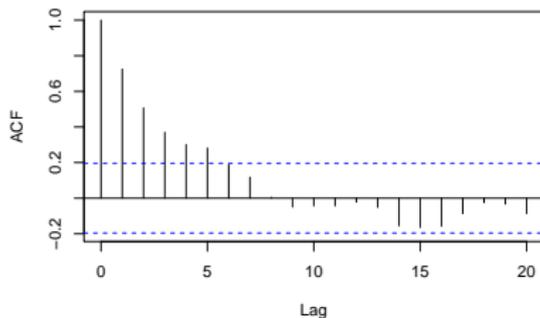
1. How to spot the dynamic process.
  2. How to test your guess.
- ▶ If you are unsure of what is going on, you can employ the **Box-Jenkins diagnostics** method .

# Review of Problem Set 1

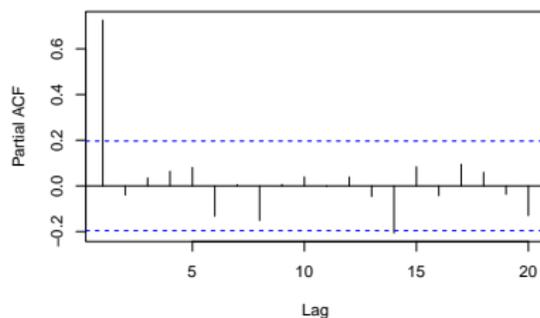
Time Series Plot



Auto Correlation Function

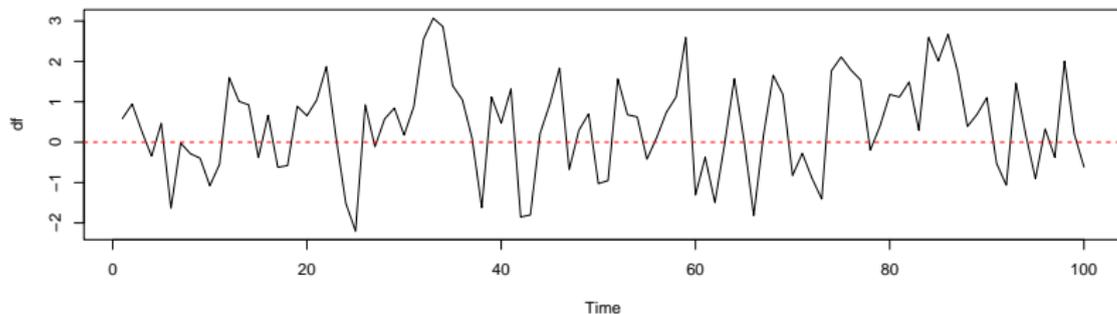


Partial Auto Correlation Function

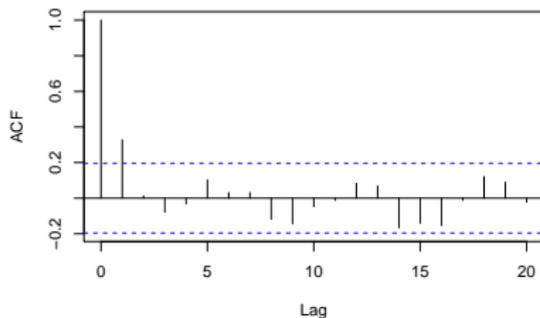


# Review of Problem Set 1

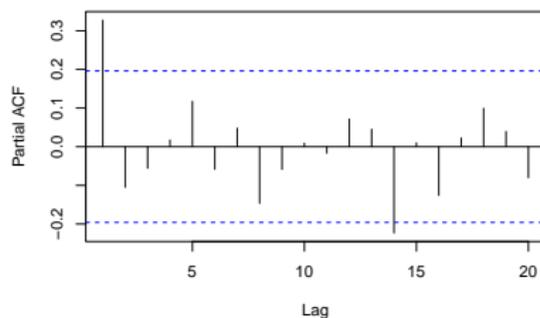
Time Series Plot



Auto Correlation Function

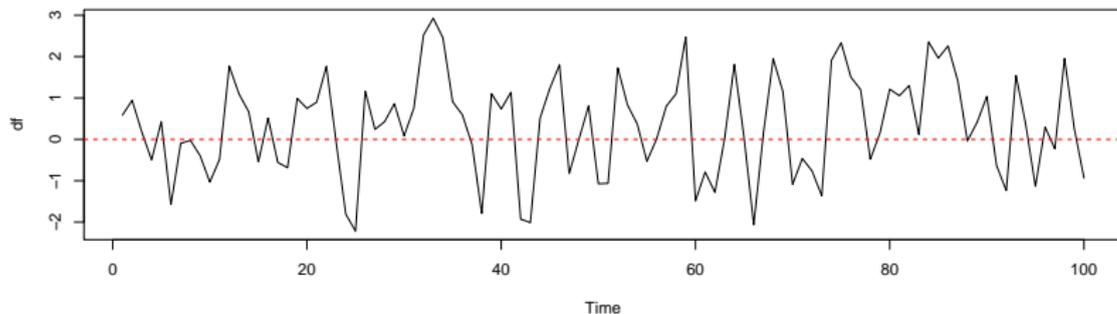


Partial Auto Correlation Function

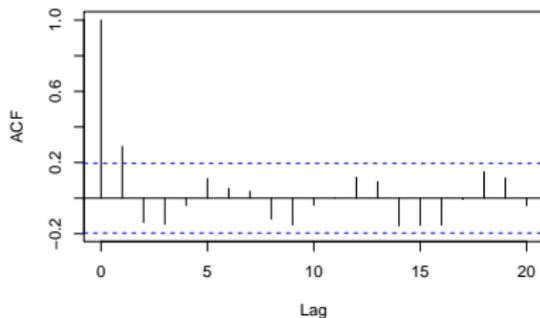


# Review of Problem Set 1

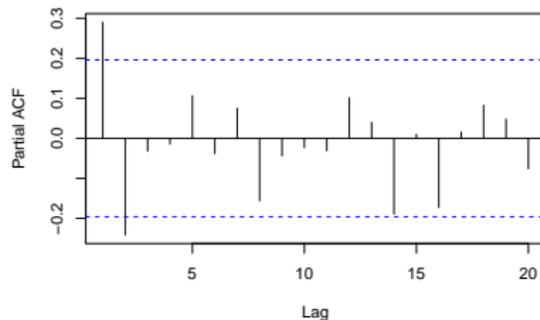
Time Series Plot



Auto Correlation Function

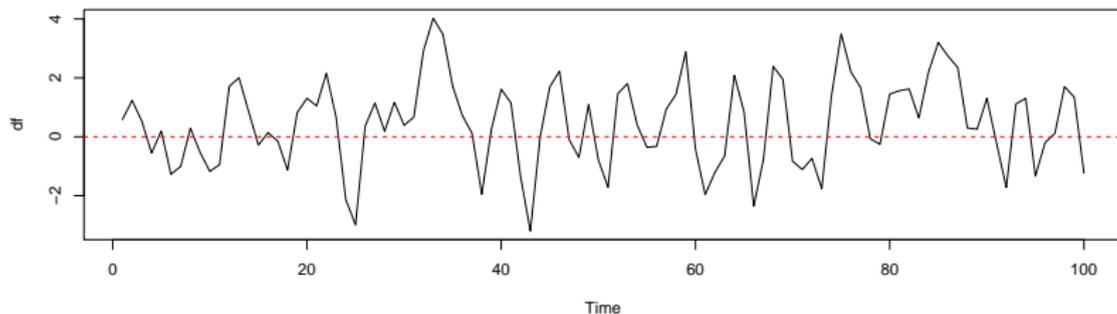


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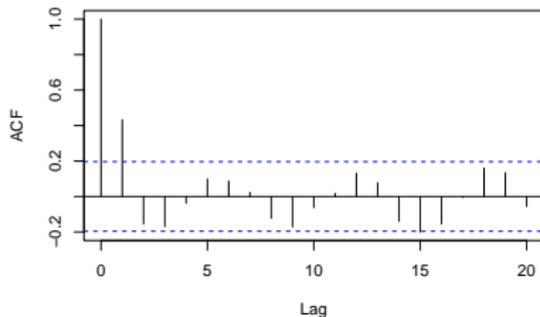


# Review of Problem Set 1

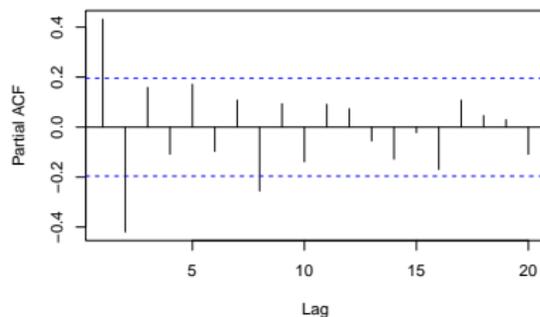
Time Series Plot



Auto Correlation Function

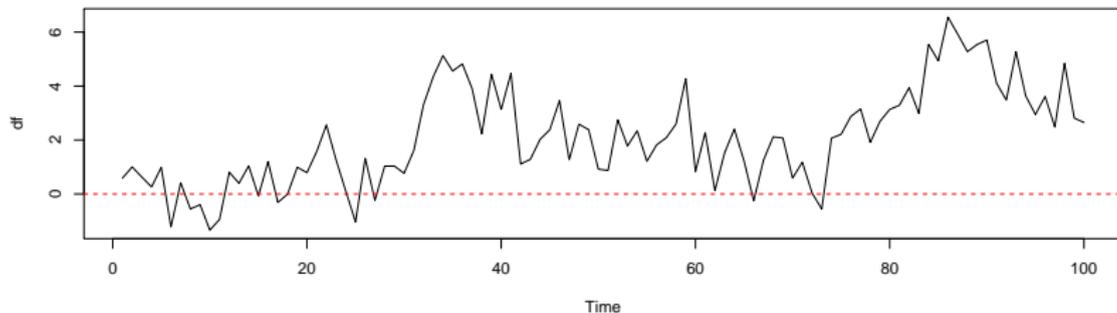


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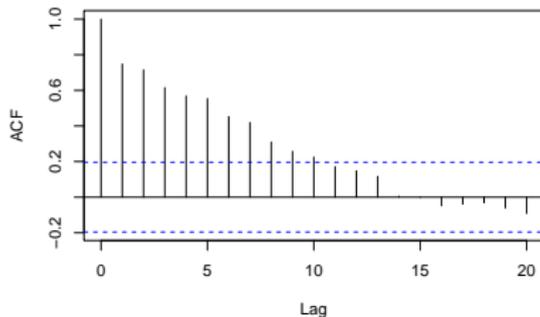


# Review of Problem Set 1

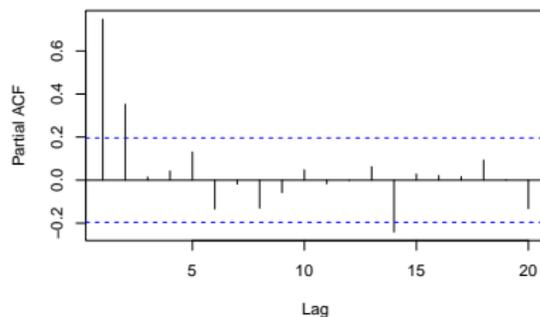
Time Series Plot



Auto Correlation Function

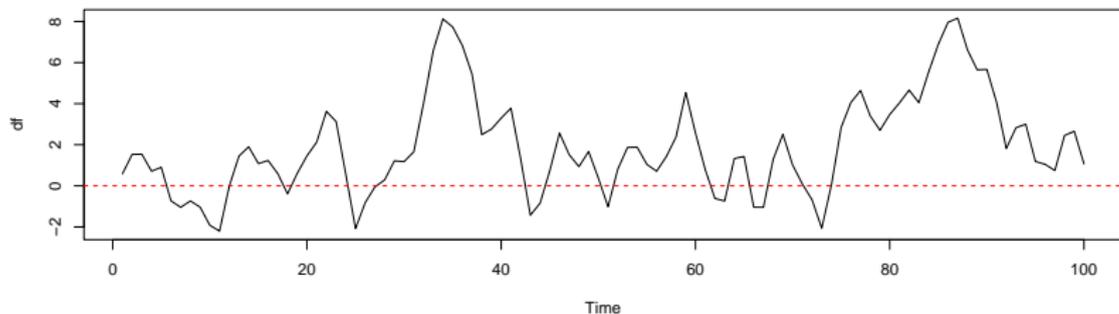


Partial Auto Correlation Function

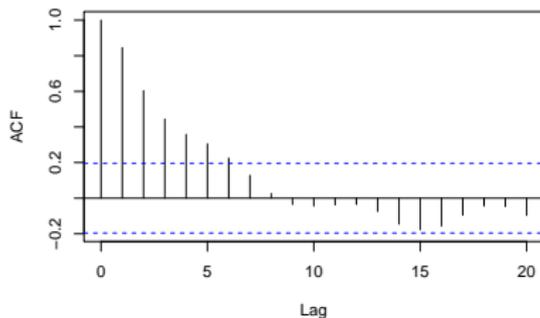


# Review of Problem Set 1

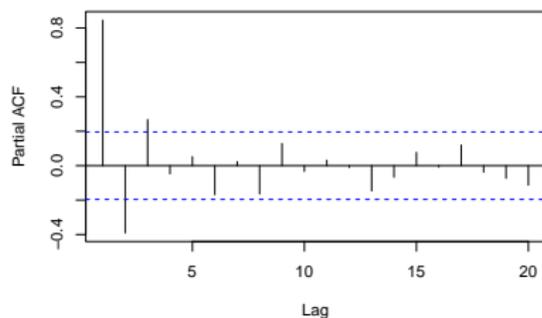
Time Series Plot



Auto Correlation Function

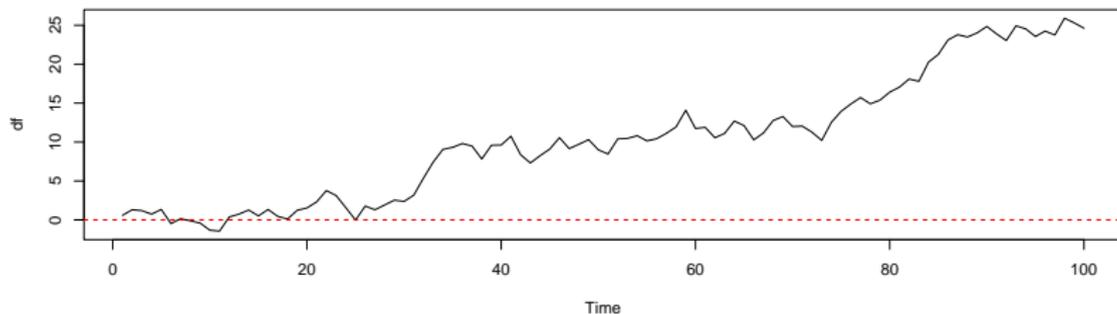


Partial Auto Correlation Function

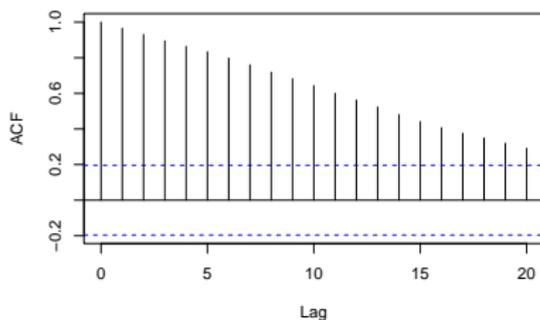


# Review of Problem Set 1

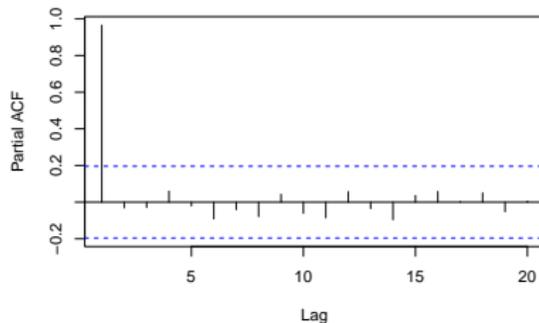
Time Series Plot



Auto Correlation Function



Partial Auto Correlation Function



# What is Non-stationary?

Recall that stationary time series have three properties:

## 1. Mean stationarity

- ▶ mean does not depend on  $t$ , constant over time
- ▶ variance also does not depend on  $t$ , constant over time

## 2. Covariance stationarity

- ▶ covariance of  $y_t$  and  $y_{t-1}$  do not depend on  $t$
- ▶ does not depend on the actual time the covariance is computed

## 3. Ergodicity

- ▶ sample moments converge in probability to the population moments
- ▶ sample mean and variance tend to be the same as entire series

Nonstationary processes lack these properties.

# What is Non-stationary?

Why do nonstationary processes matter?

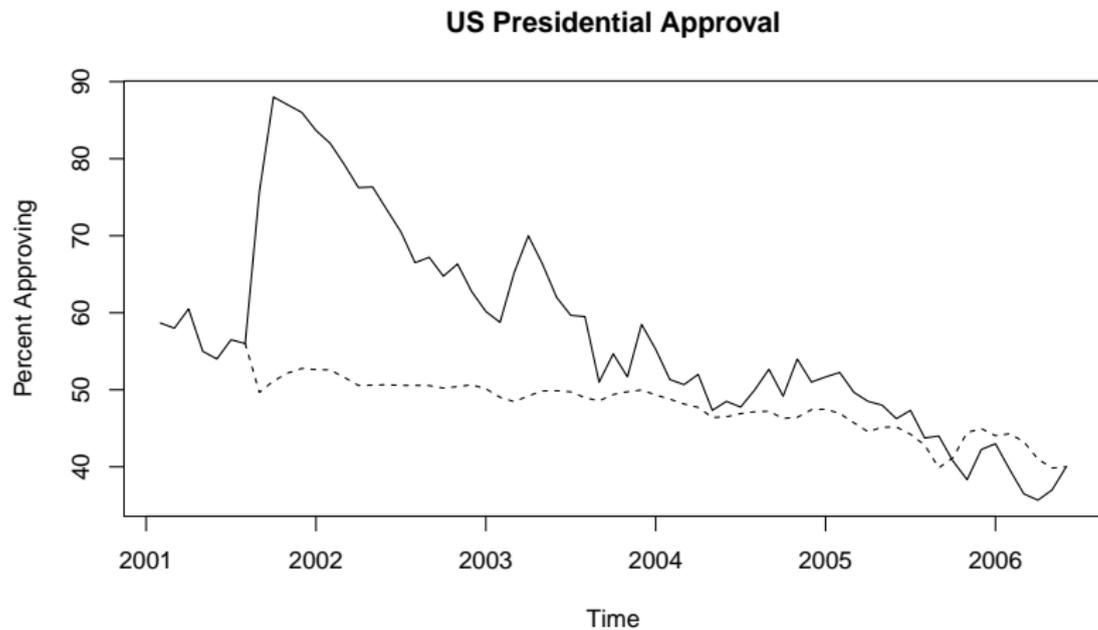
1. ACF and PACF **not defined** since the covariances in the nominator depend on  $t$
2. **Spurious regression**: we may detect strong correlations between nonstationary processes although they could be conditionally (mean) independent.
3. Long run forecasts are **unfeasible** since the process does not revert to its mean.

# What is Non-stationary?

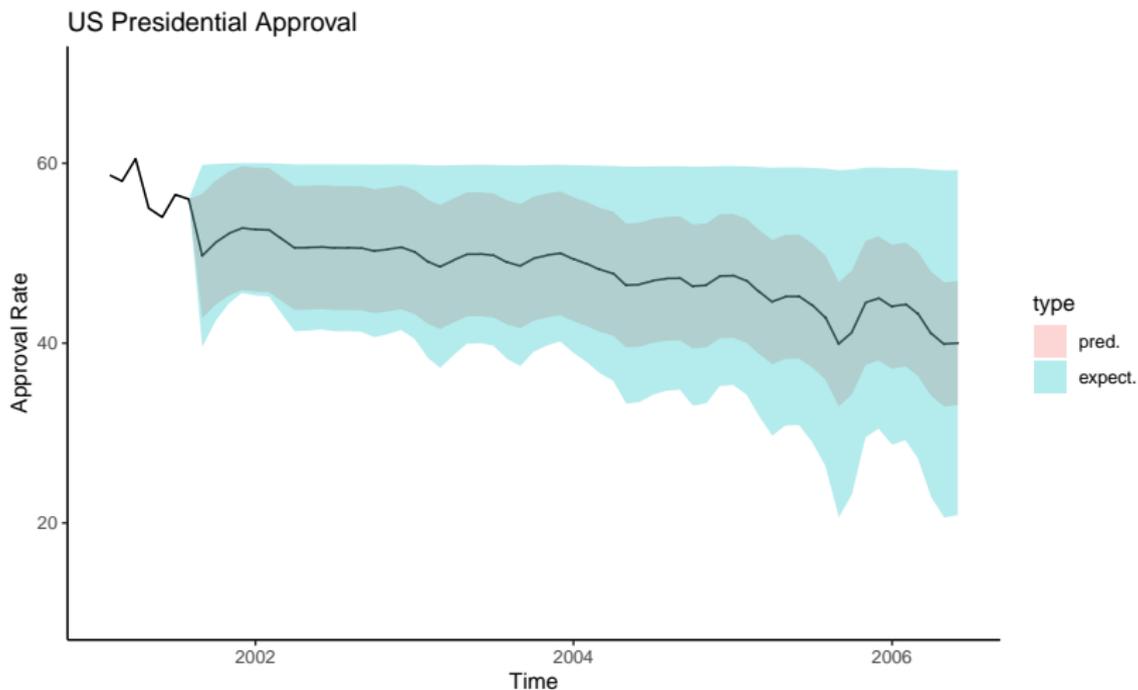
Solutions?

1. Analyze nonstationary process using ARIMA (differencing)
  - ▶ effective at capturing short run changes
  - ▶ outcome is transformed to a difference
  - ▶ long-run predictions not feasible
2. Analyze nonstationary process using cointegration
  - ▶ effective at capturing long run relationships between nonstationary processes
  - ▶ outcome is left as a level
  - ▶ short-run and long-run predictions feasible
  - ▶ appropriate for analyzing multiple time series

# Nonstationary: Counterfactual



# Nonstationary: Counterfactual



# Let's get started!

Please, open the file [Lab4.Rmd](#).