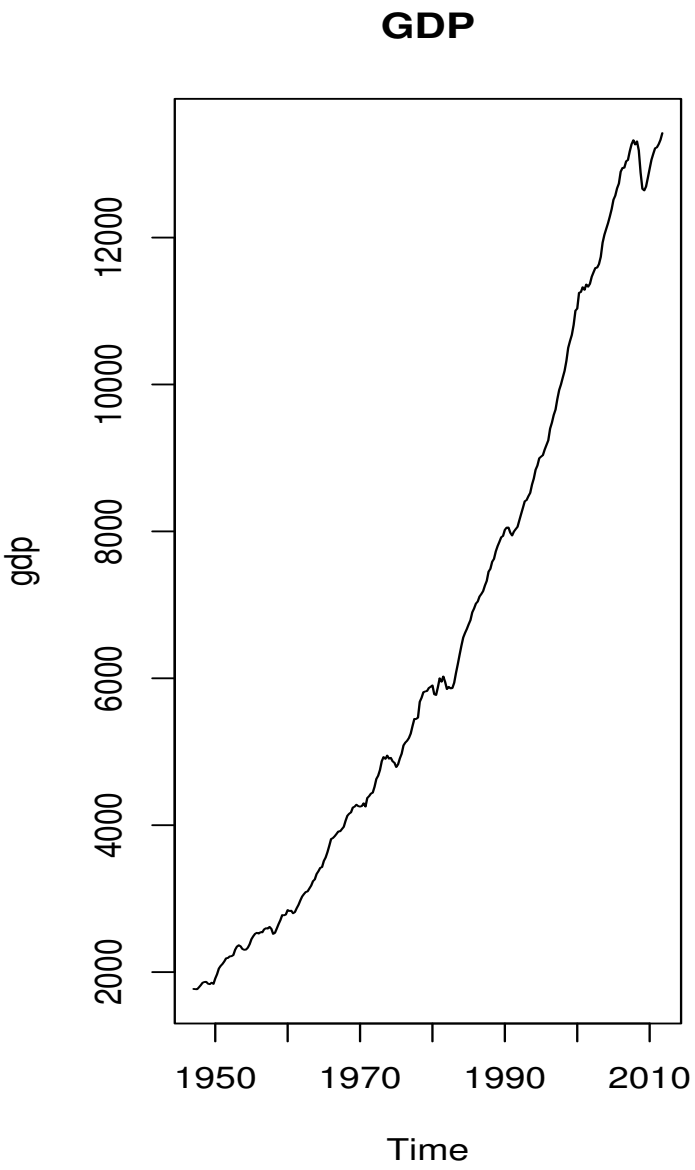
Lecture 2: Basic Time Series Modeling

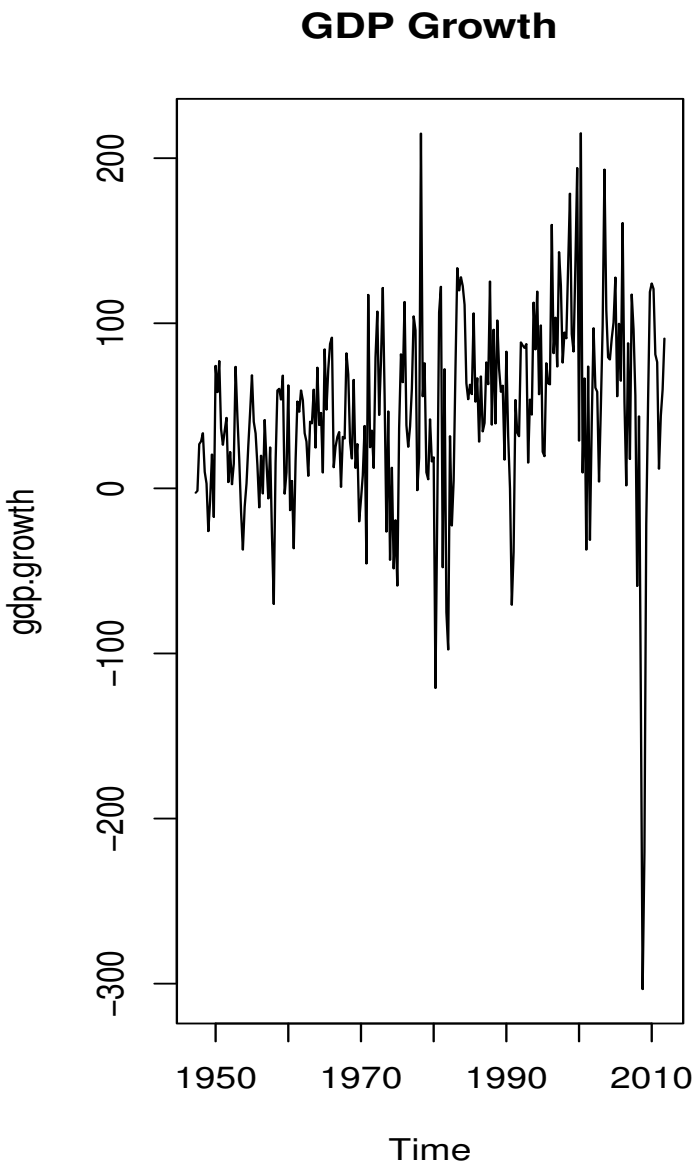
(Jing Li, Miami University)

Big Picture

1. A key issue in time series analysis is stationarity
2. A time series plot or unit root test can indicate whether a time series is stationary or nonstationary
3. A time series is nonstationary (having unit roots) if it is (1) trending; (2) smooth; (3) showing breaks/structural changes
4. A time series is stationary if it is (1) mean-reverting (no trend); (2) choppy; (3) showing no breaks
5. Usually after taking difference, a nonstationary time series becomes stationary

Time Series Plot





GDP

1. US real GDP is nonstationary since it has an upward trend and smooth
2. Because it is not mean-reverting, the average of GDP is irrelevant or meaningless
3. Many results in statistics become invalid for GDP such as $var(\bar{y}) = \frac{\sigma^2}{n}$ and law of large number $\bar{y} \rightarrow^p E(y)$ as $t \rightarrow \infty$

Modeling GDP

1. Given the trend shown by GDP, we may try
   (a) linear trend model $y = \beta t + u$
   (b) log linear trend model $log(y) = \beta t + u$
   (c) quadratic trend model $y = \beta t + \alpha t^2 + u$
2. Given the smoothness, we may try trigonometric model $y = \beta \sin(kt) + \alpha \cos(kt) + u$
3. We may add lagged values to account for persistence, for example,
   $y_t = \beta t + \alpha t^2 + \gamma y_{t-1} + u$
4. We hope the model is adequate so that no information is left in the error term u. In other words we hope error term is as unpredictable as white noise.

Modeling GDP Growth

1. We obtain GDP growth after taking (log) difference of GDP
2. GDP growth is stationary since it is not trending and chopy
3. We can apply ARMA model to GDP growth