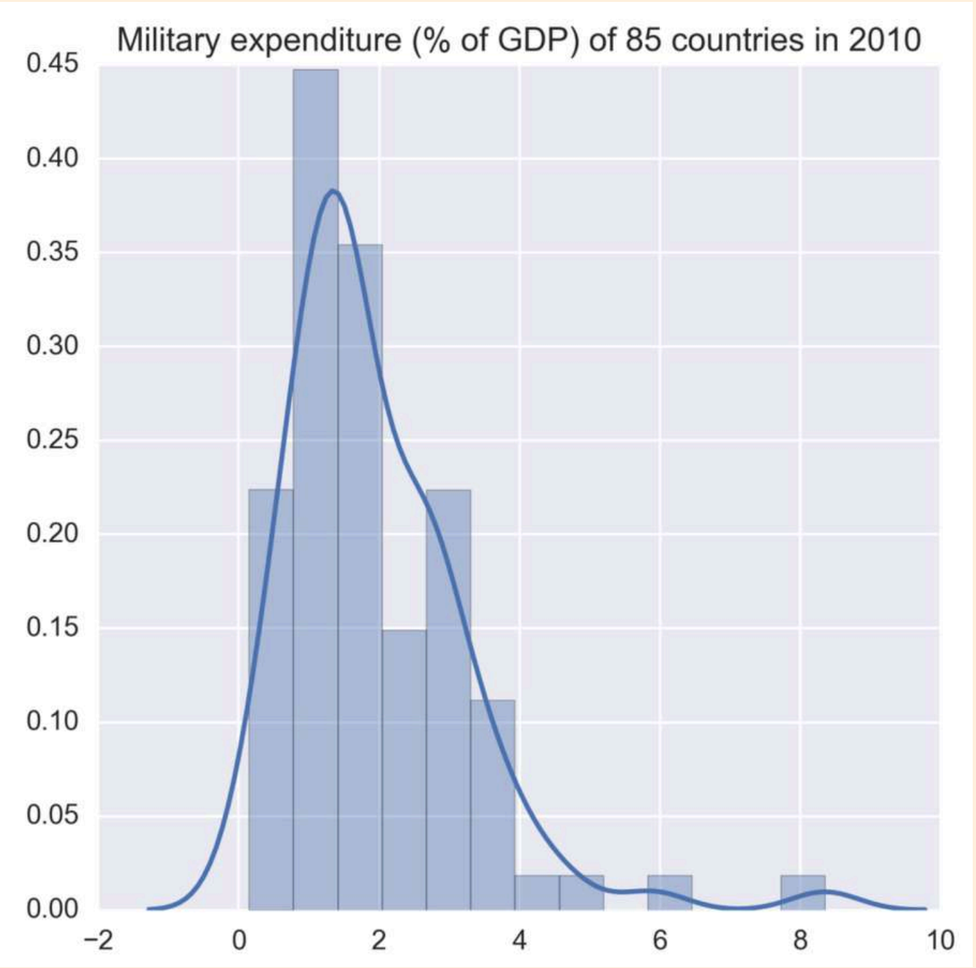
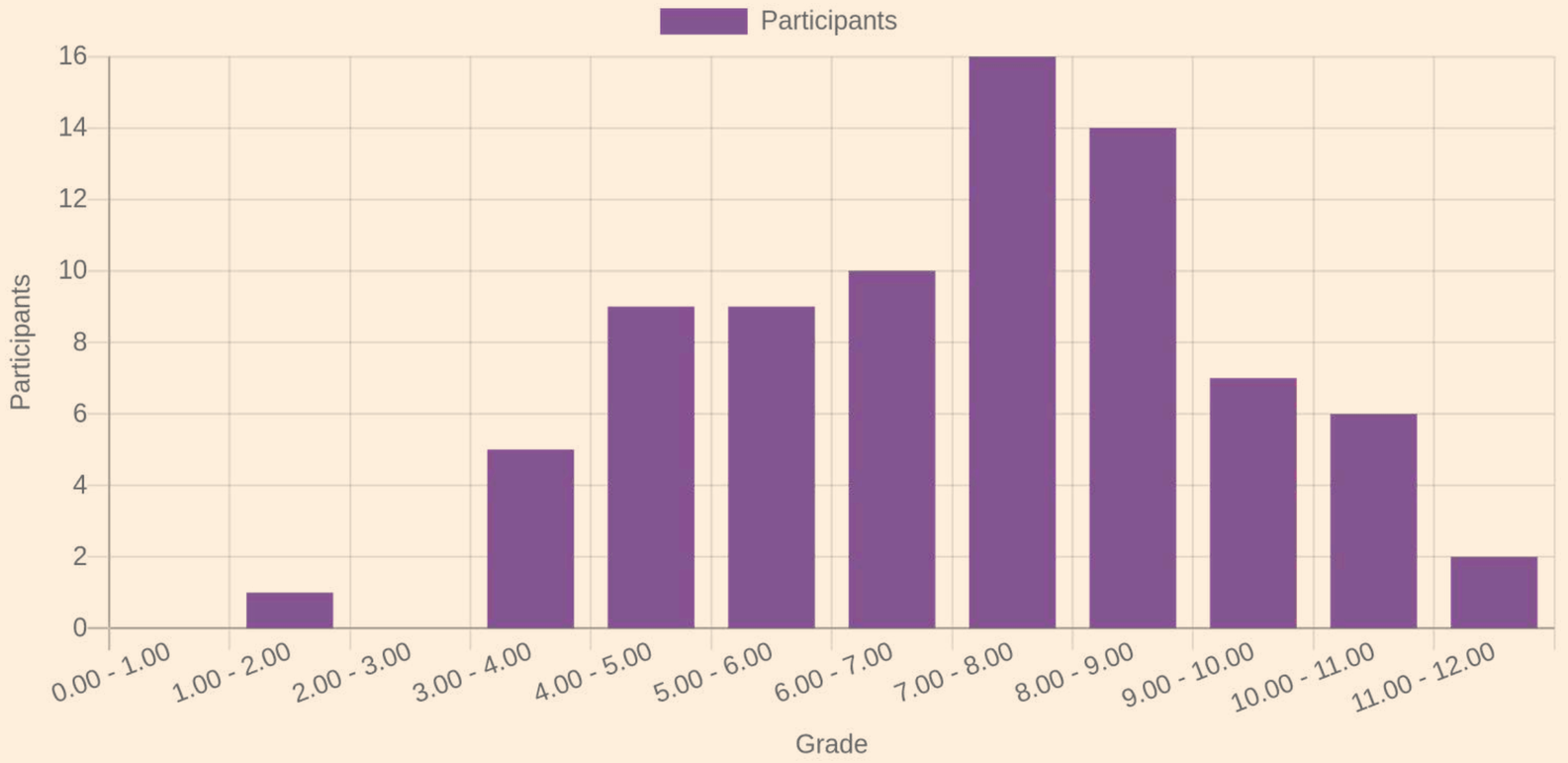
॥ त्वं ज्ञानमयो विज्ञानमयोऽसि ॥

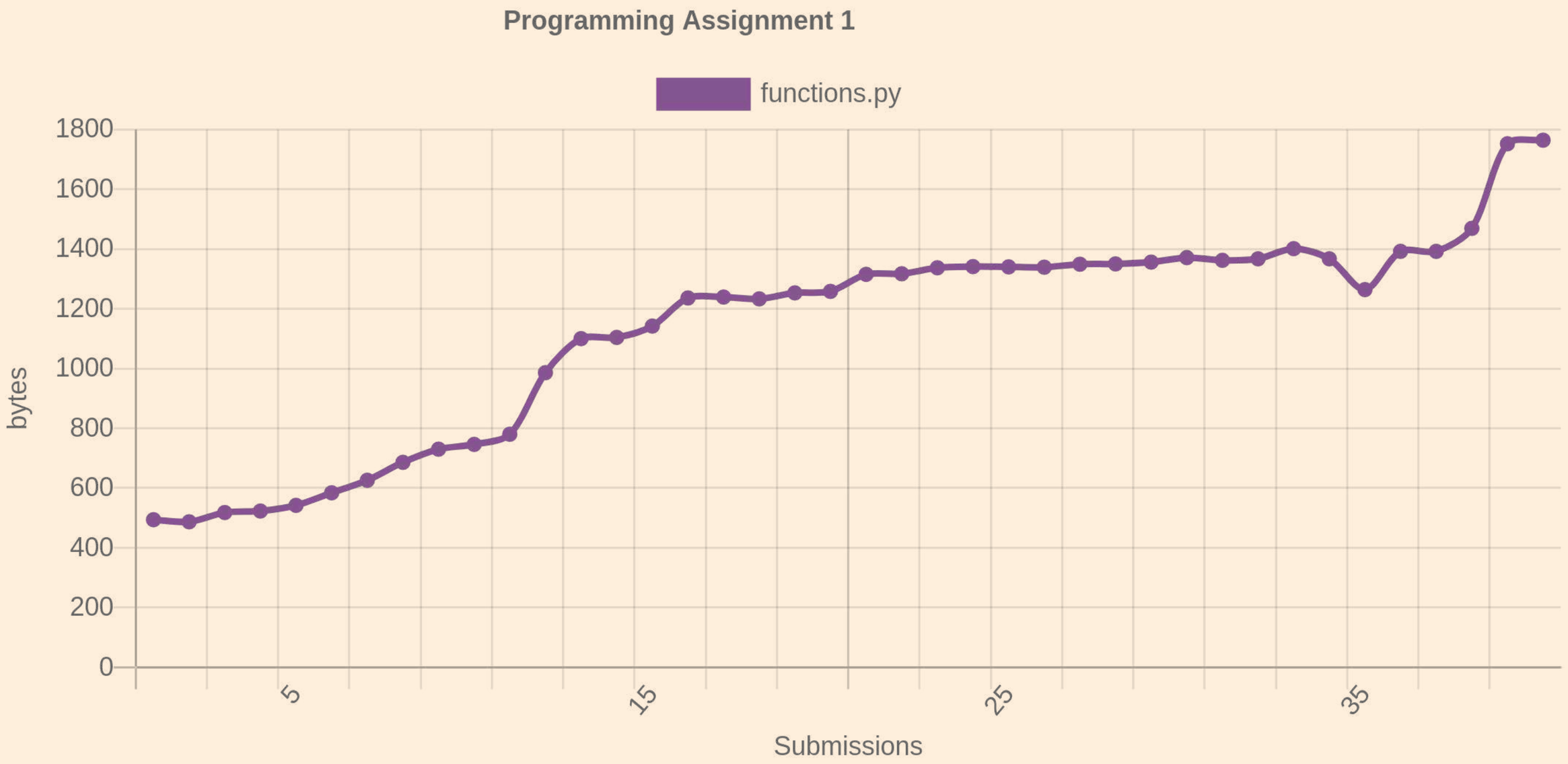
Time Series Visualization

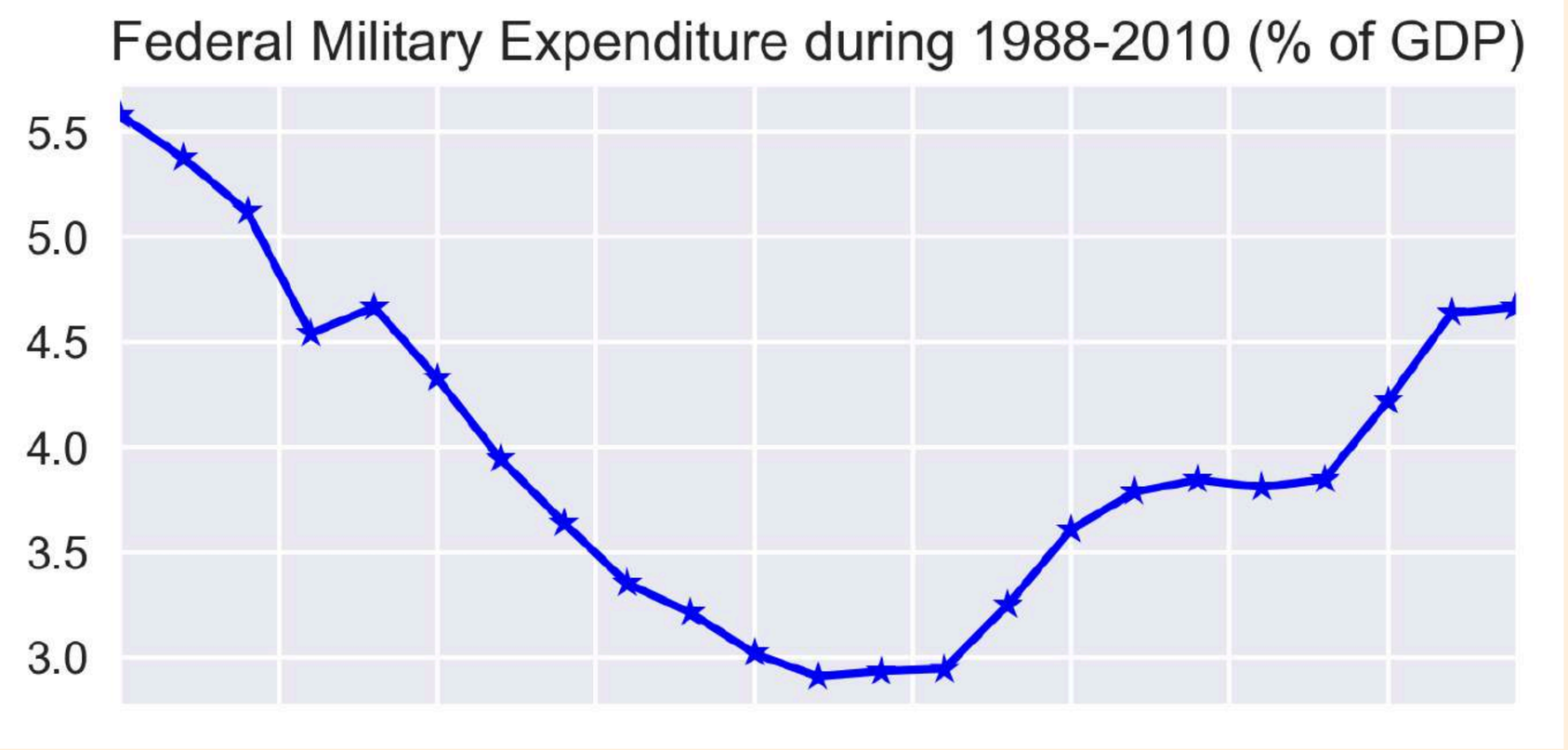
Trend Visualization

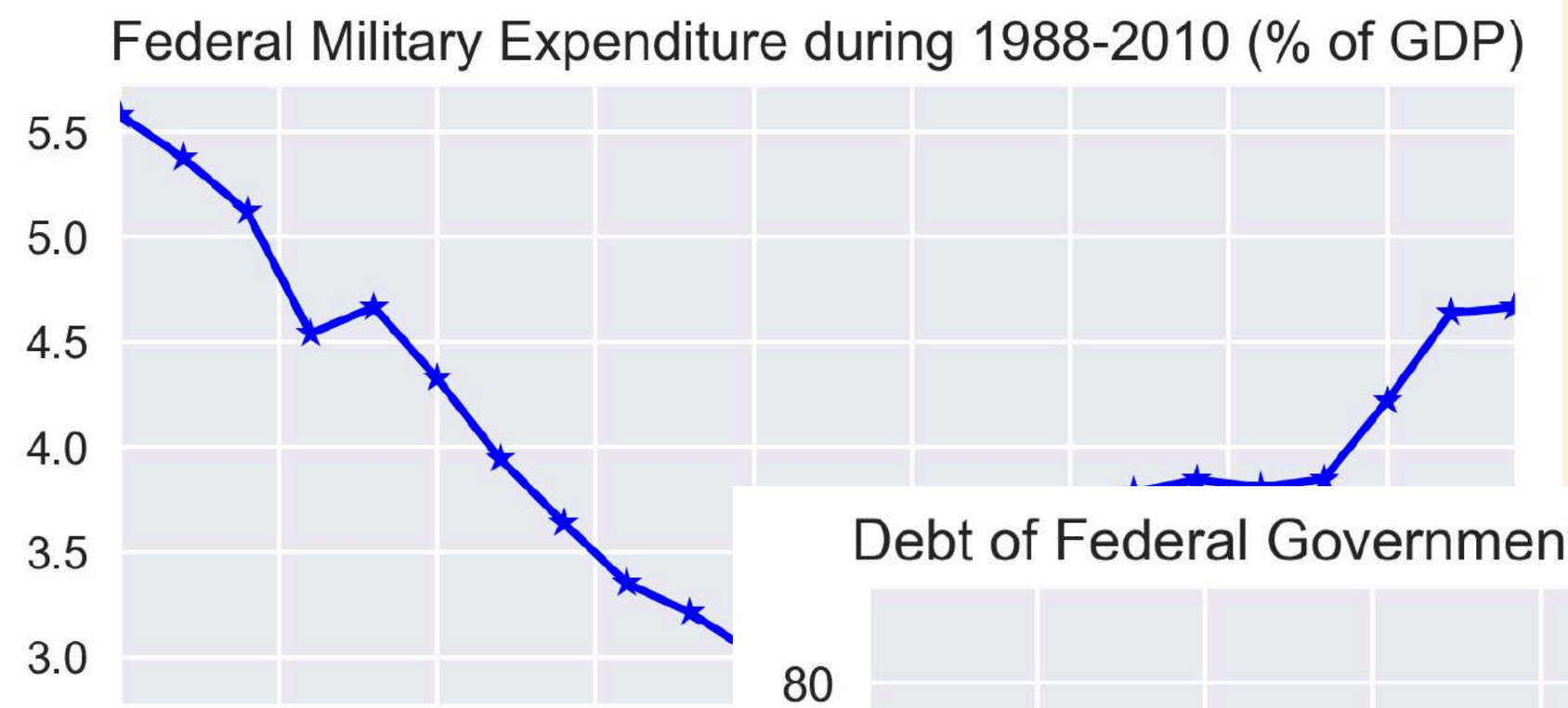
S. Kundu Ph.D.

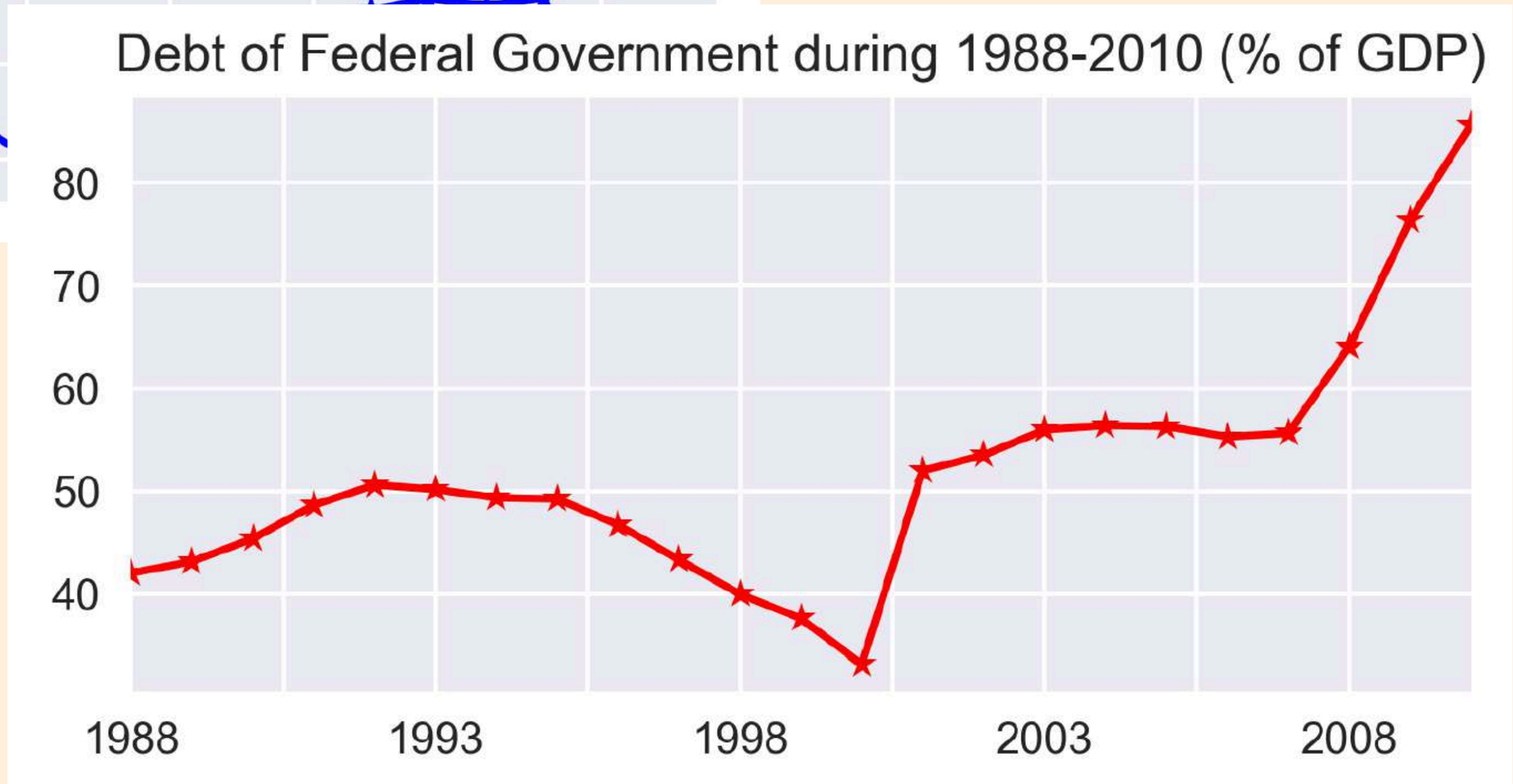

Military expenditure (% of GDP) of 85 countries in 2010
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
−2
0
2
4
6
8
10

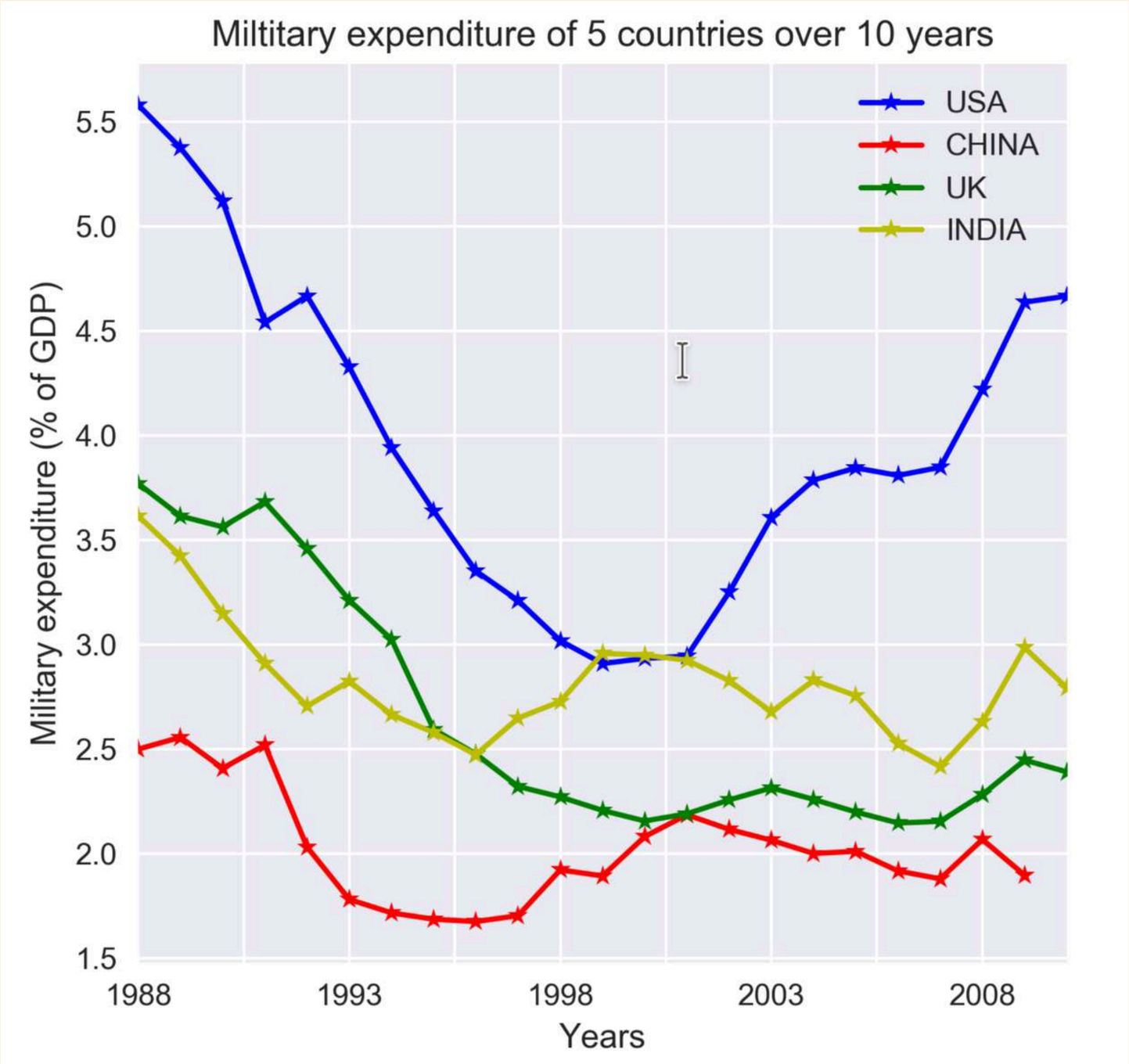

Participants
16
14
12
10
8
6
4
2
0
Participants
0.00 - 1.00
1.00 - 2.00
2.00 - 3.00
3.00 - 4.00
4.00 - 5.00
5.00 - 6.00
6.00 - 7.00
7.00 - 8.00
8.00 - 9.00
9.00 - 10.00
10.00 - 11.00
11.00 - 12.00
Grade


Programming Assignment 1
functions.py
1800
1600
1400
1200
1000
800
600
400
200
0
bytes
5
15
25
35
Submissions

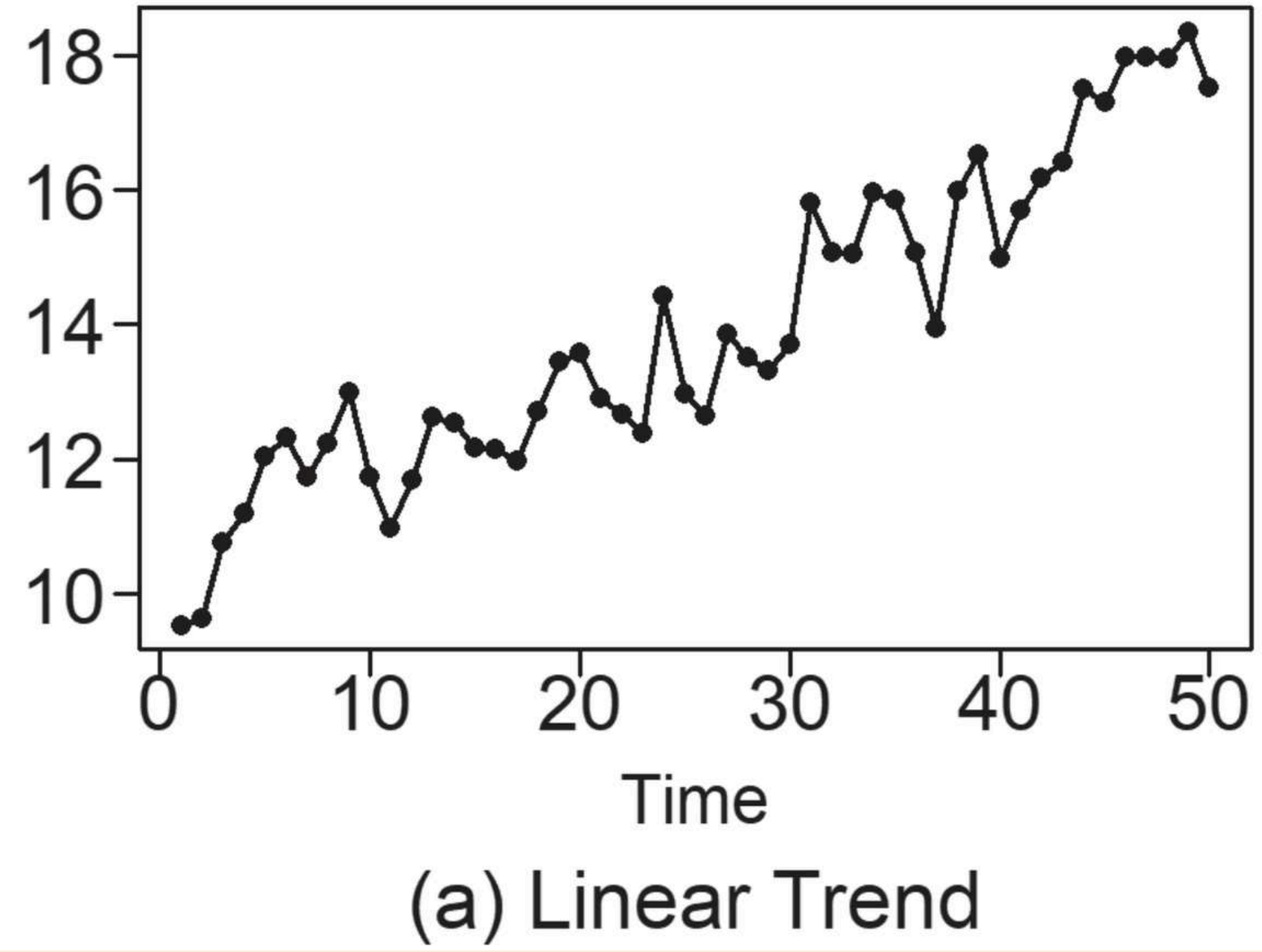

Federal Military Expenditure during 1988-2010 (% of GDP)
5.5
5.0
4.5
4.0
3.5
3.0


Federal Military Expenditure during 1988-2010 (% of GDP)
5.5
5.0
4.5
4.0
3.5
3.0

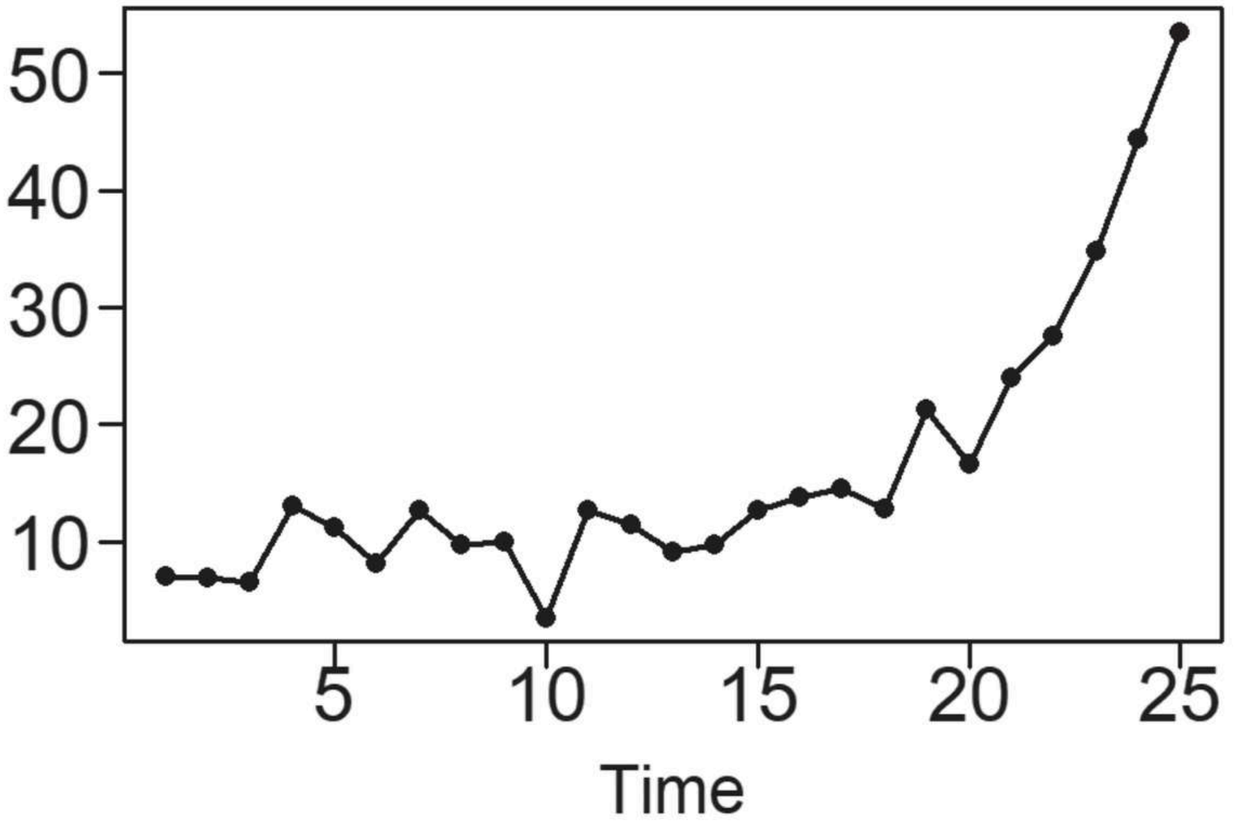

Debt of Federal Government during 1988-2010 (% of GDP)
80
70
60
50
40
1988
1993
1998
2003
2008


Miltitary expenditure of 5 countries over 10 years
USA
CHINA
UK
INDIA
Military expenditure (% of GDP)
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1988
1993
1998
2003
2008
Years

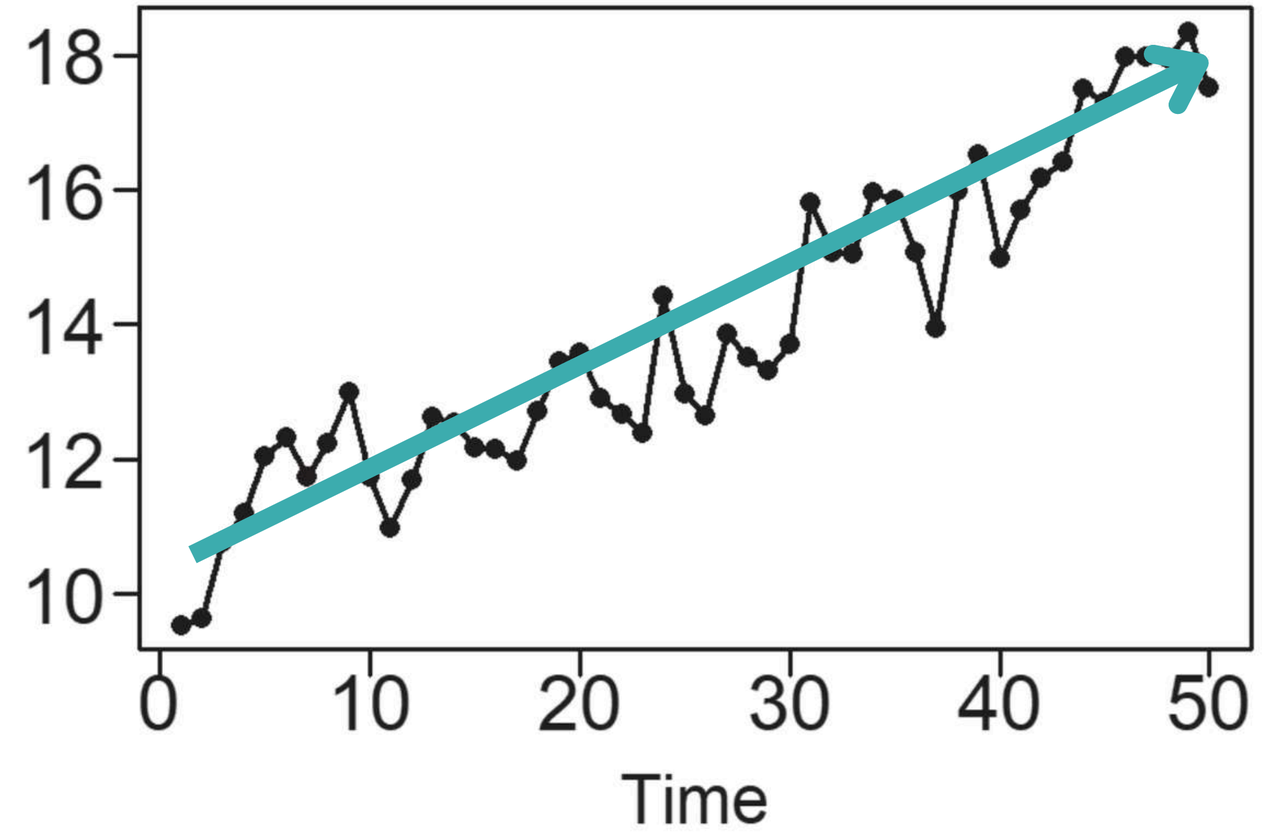
#2474



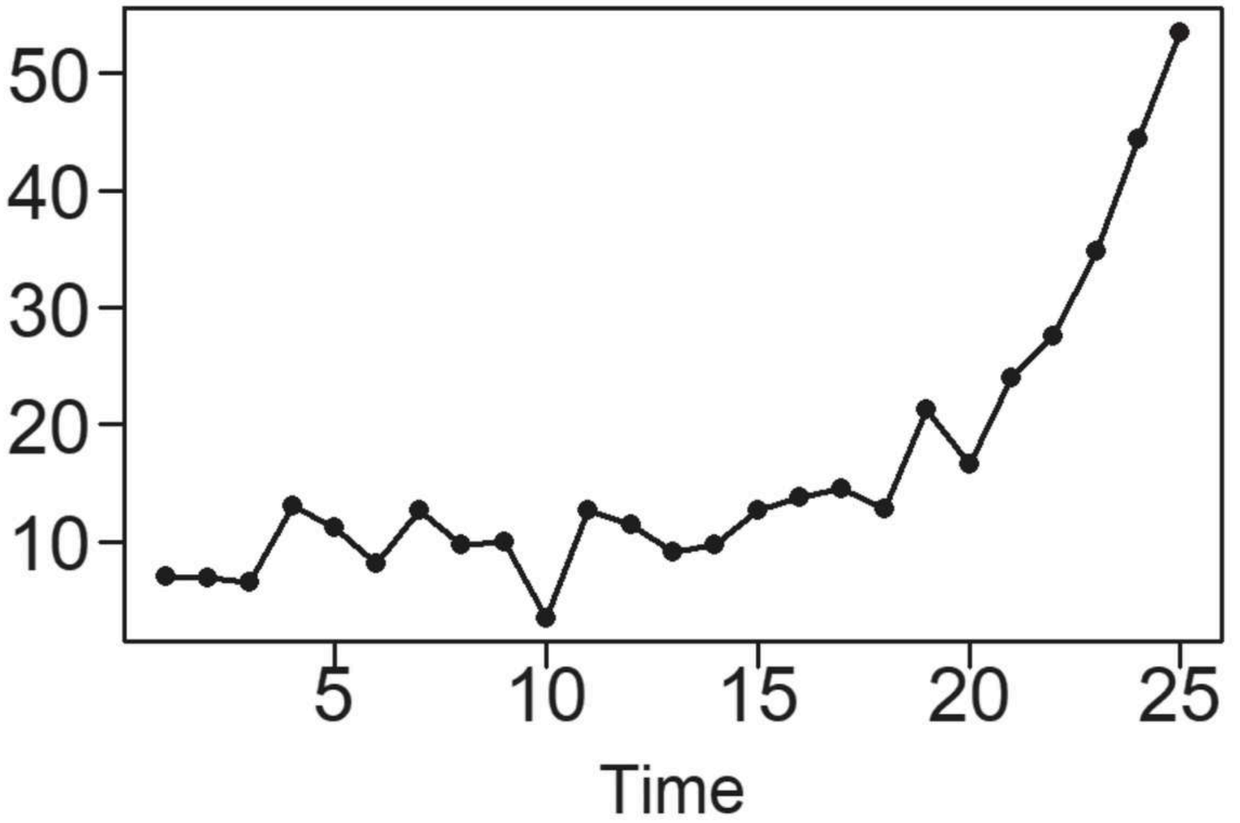
(a) Linear Trend



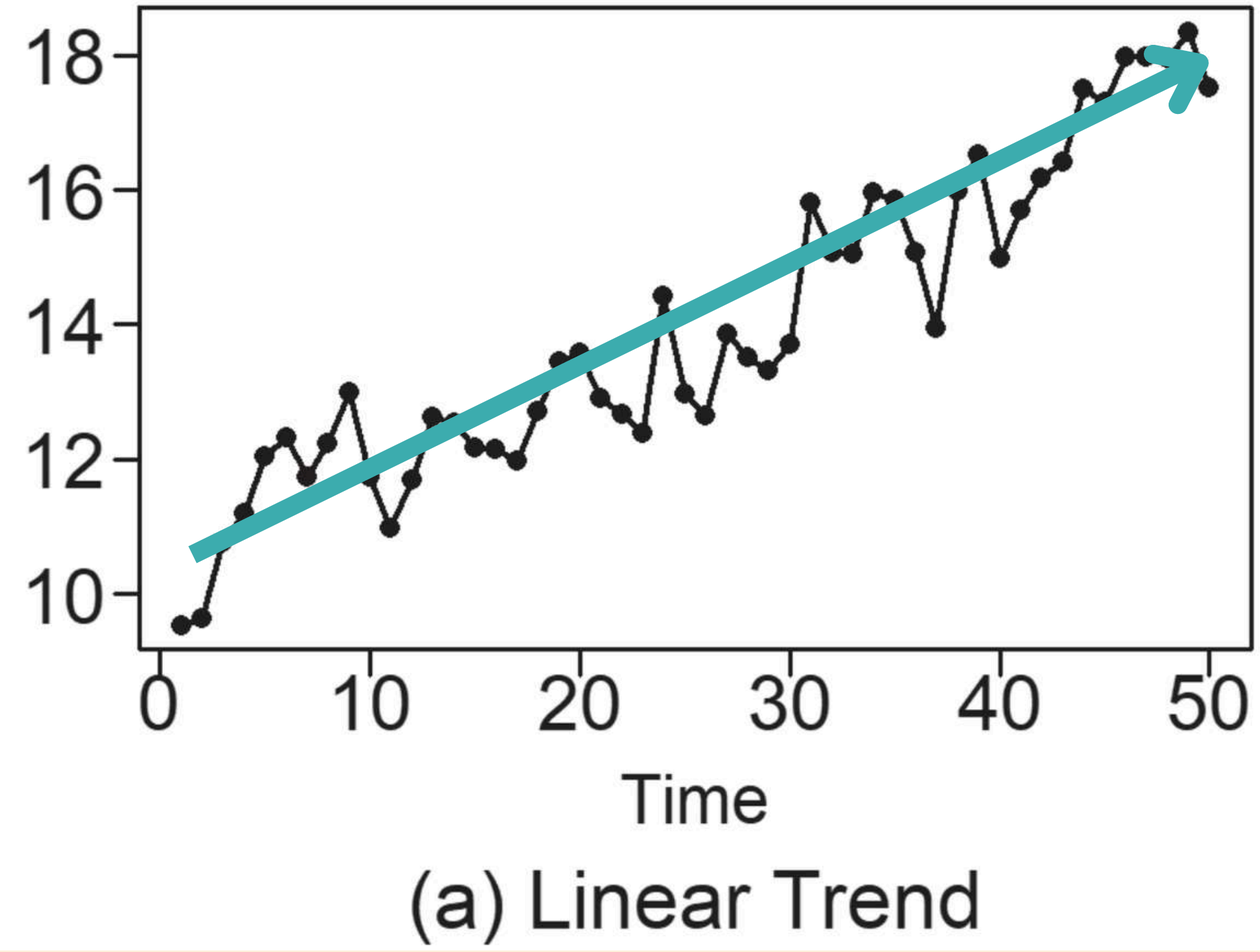
(b) Exponential Trend



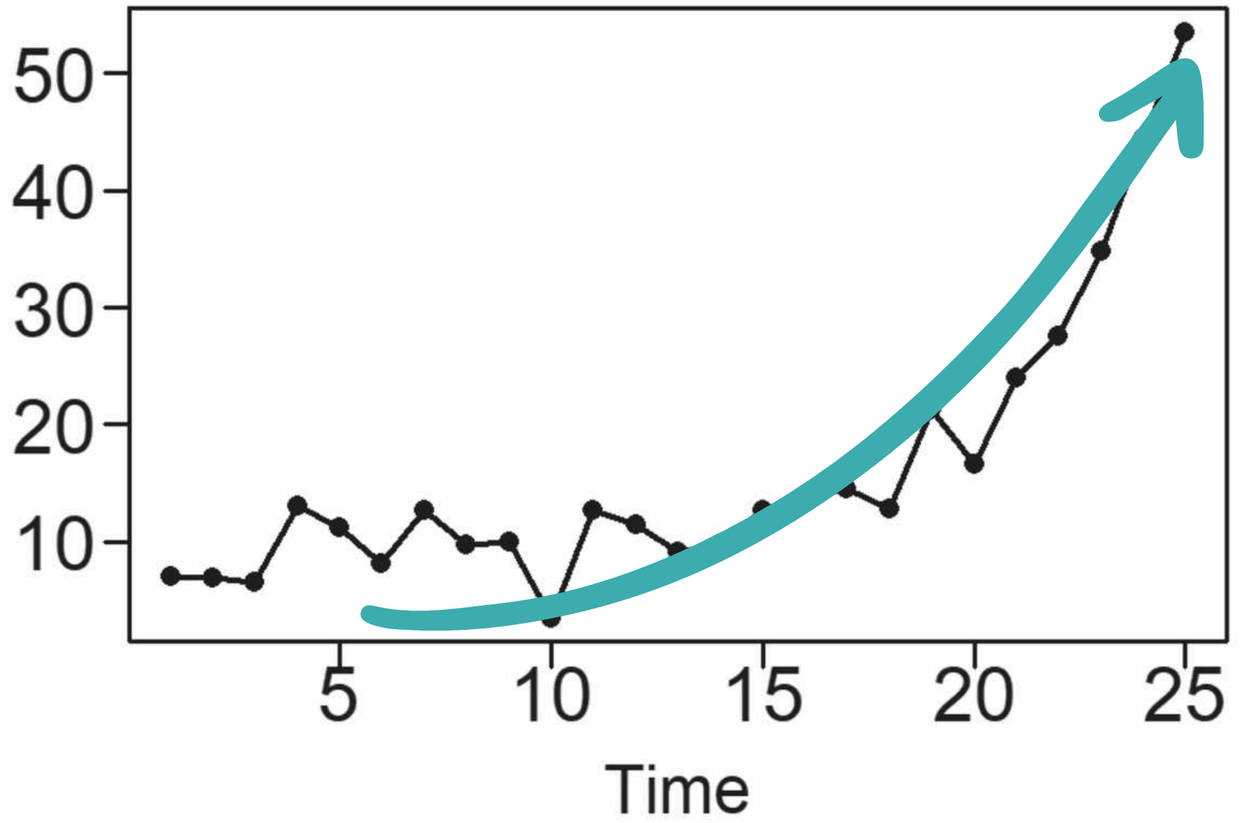
(a) Linear Trend



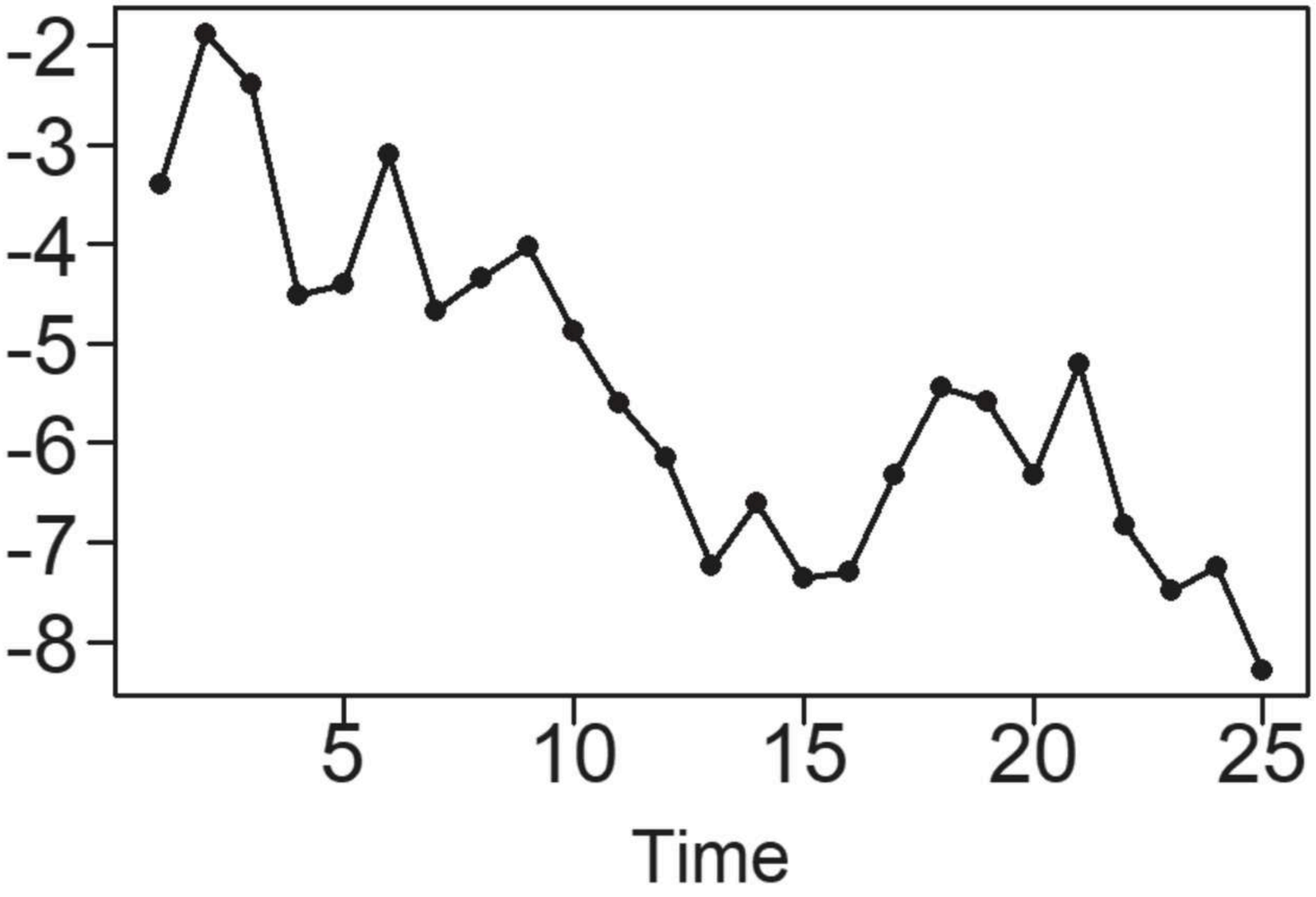
(b) Exponential Trend



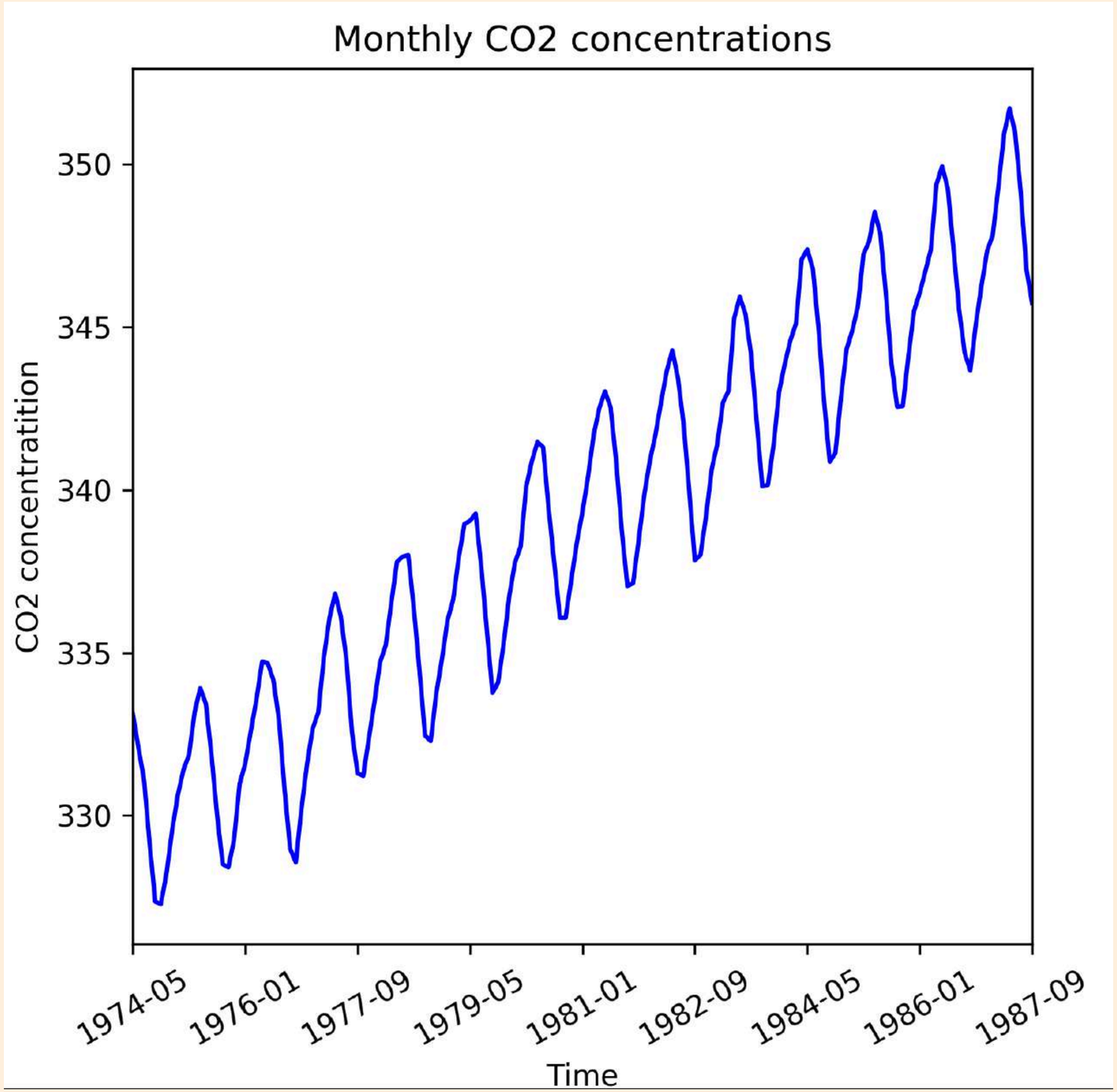
(a) Linear Trend



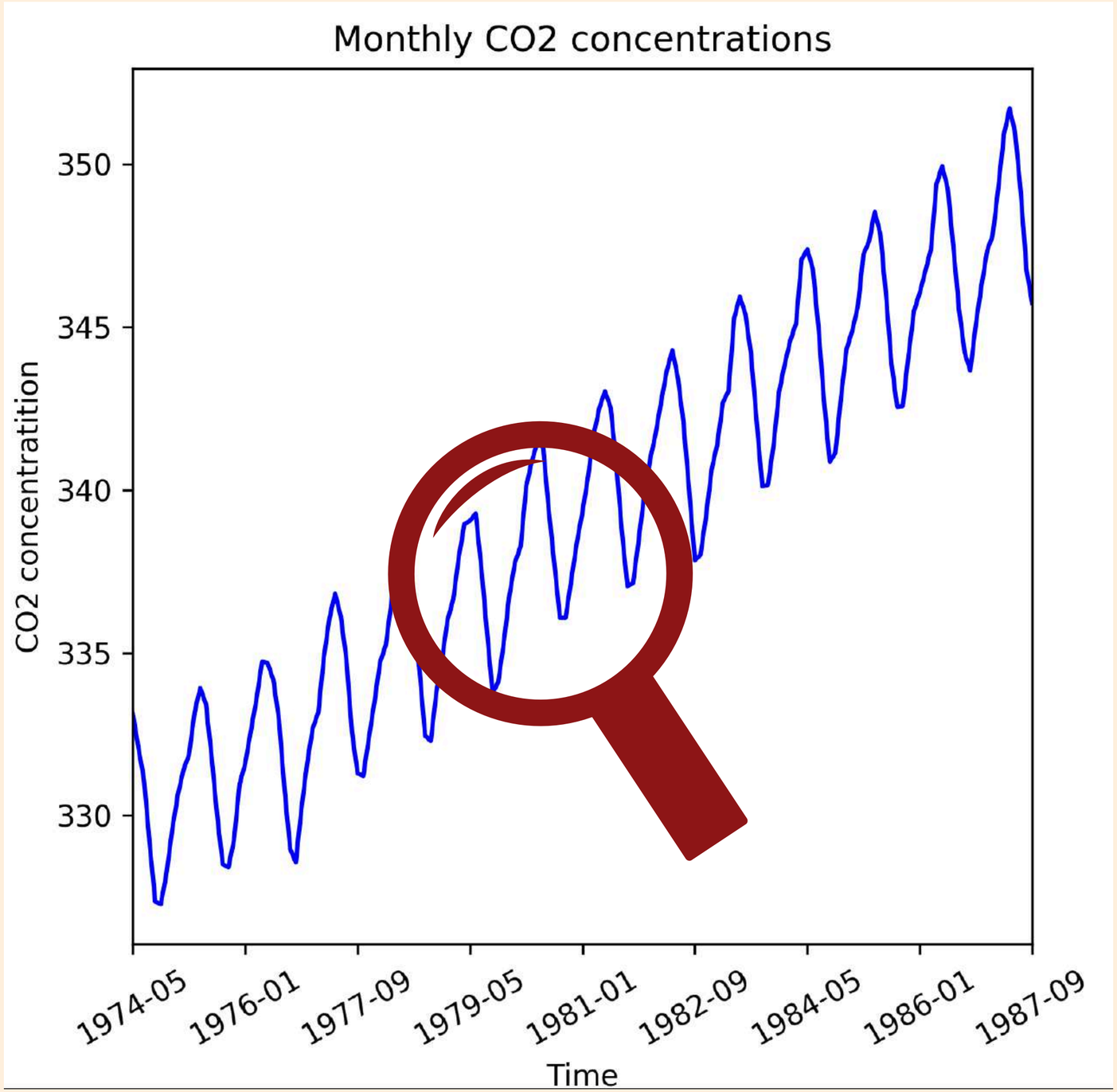
(b) Exponential Trend

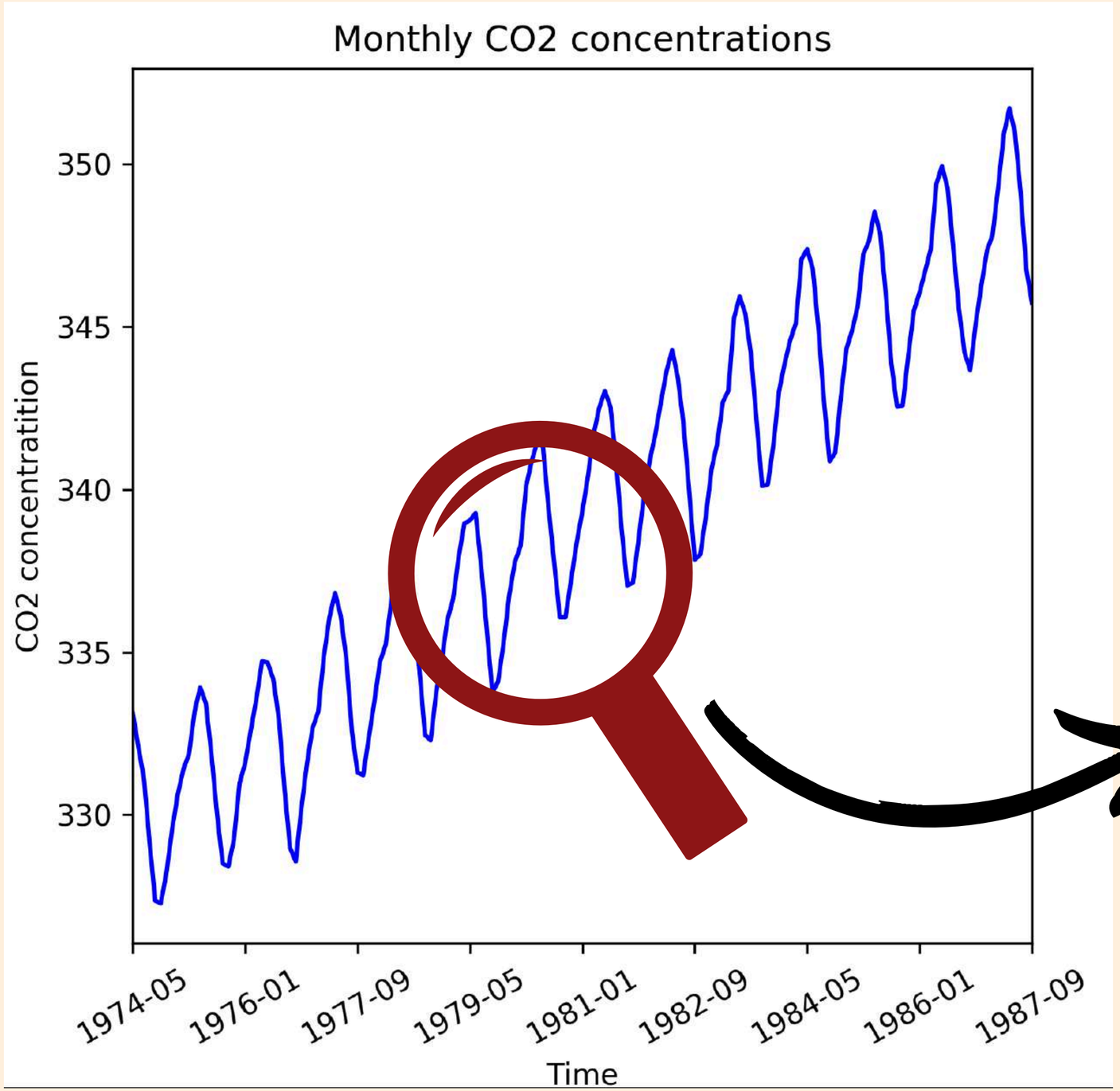


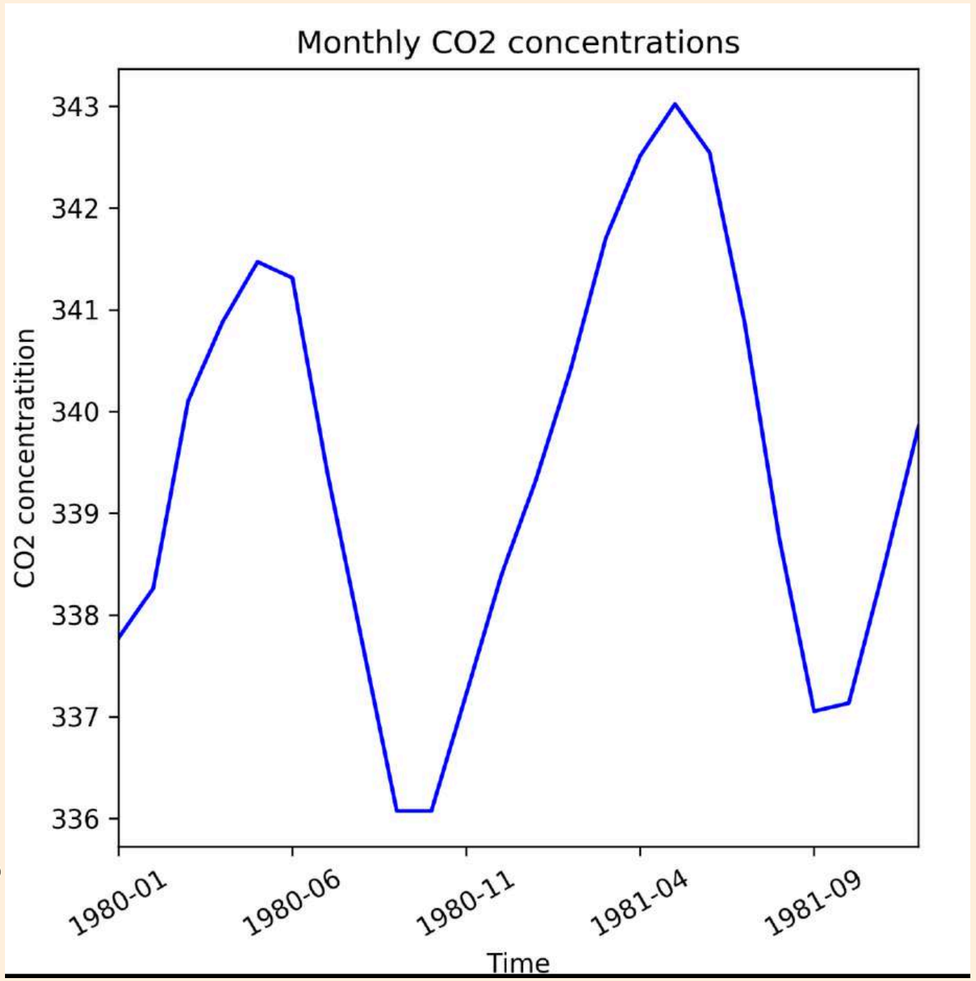
(c) Downward Trend


Monthly CO2 concentrations
CO2 concentratition
350
345
340
335
330
1974-05
1976-01
1977-09
1979-05
1981-01
1982-09
1984-05
1986-01
1987-09
Time

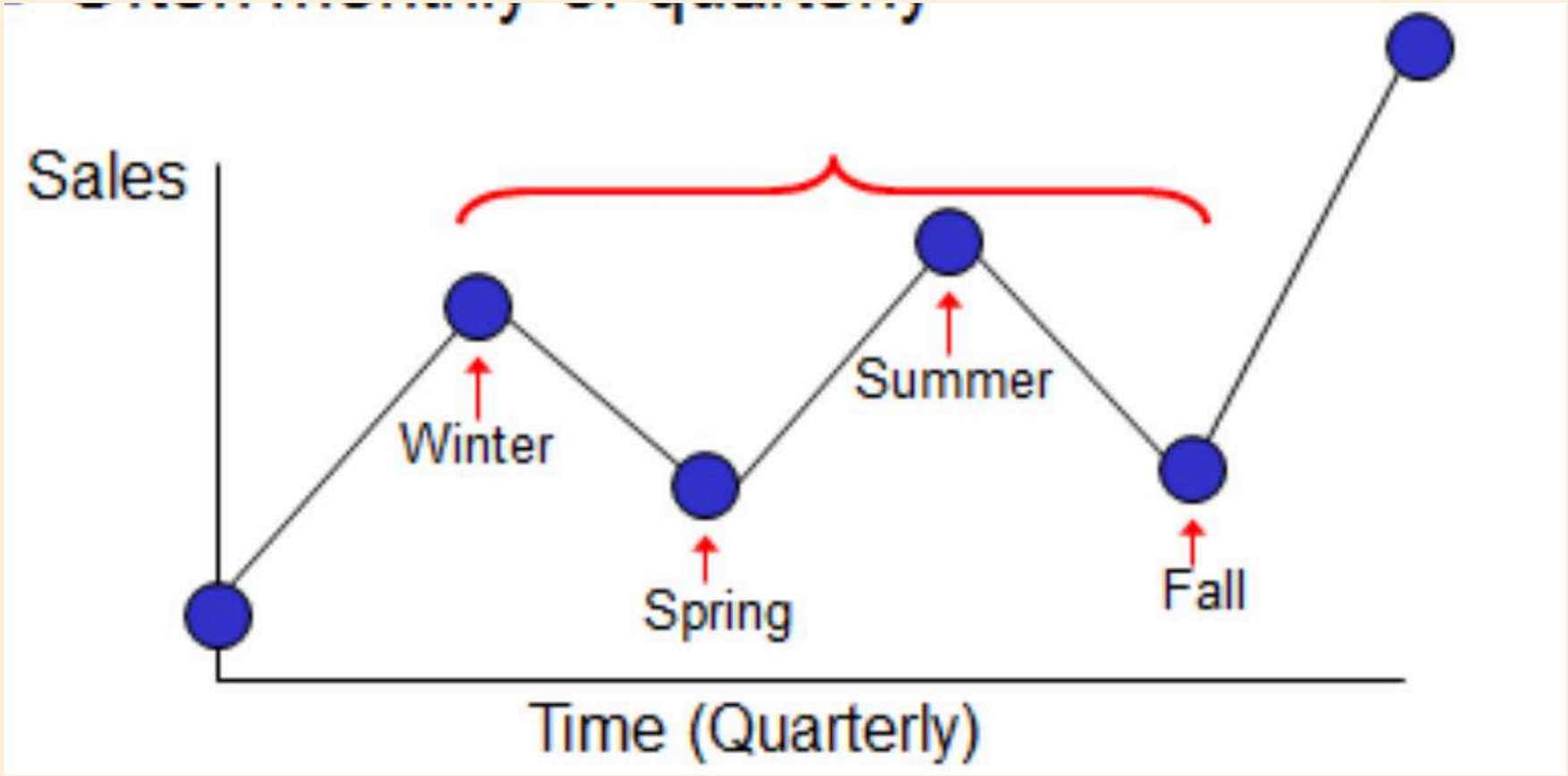
#2474

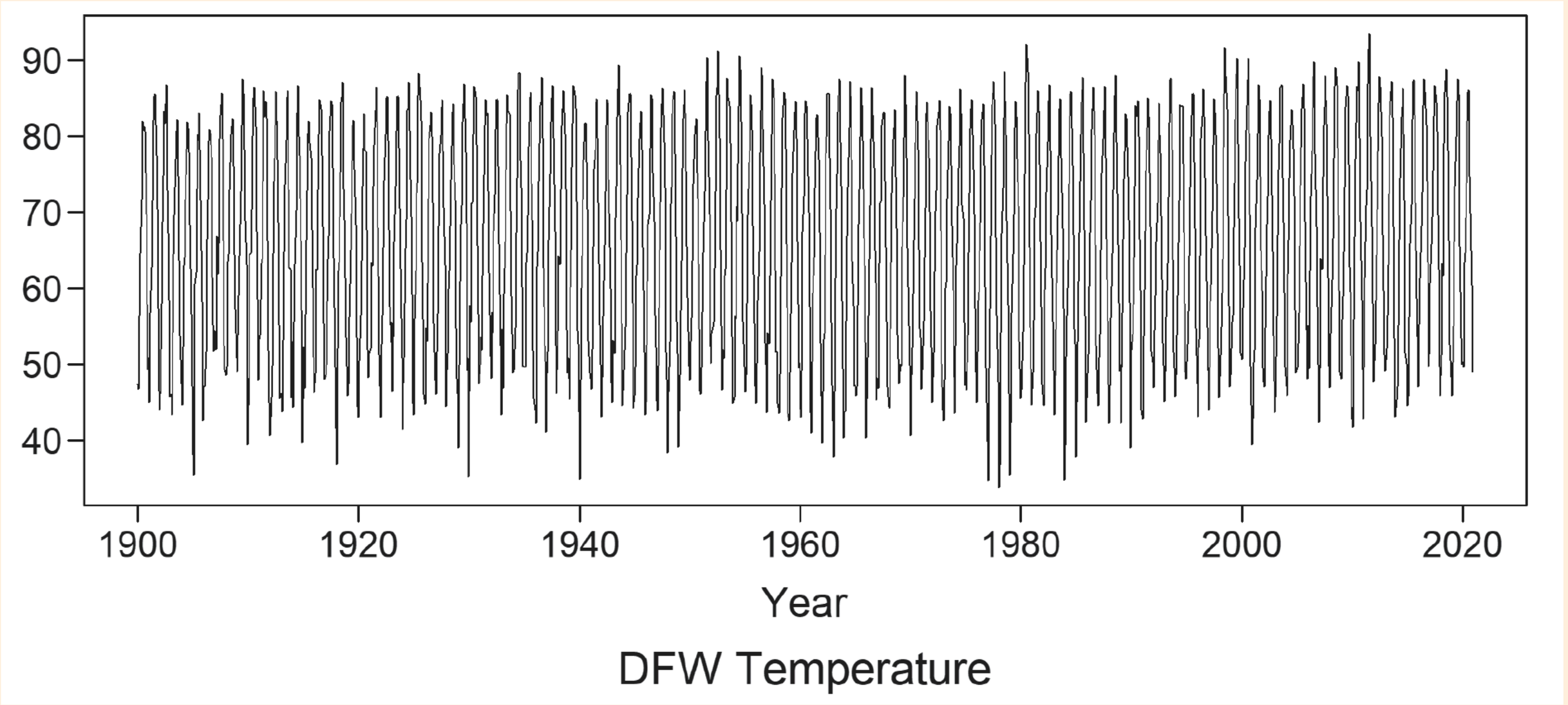

Monthly CO2 concentrations
CO2 concentratition
350
345
340
335
330
1974-05
1976-01
1977-09
1979-05
1981-01
1982-09
1984-05
1986-01
1987-09
Time


Monthly CO2 concentrations
CO2 concentratition
350
345
340
335
330
1974-05
1976-01
1977-09
1979-05
1981-01
1982-09
1984-05
1986-01
1987-09
Time

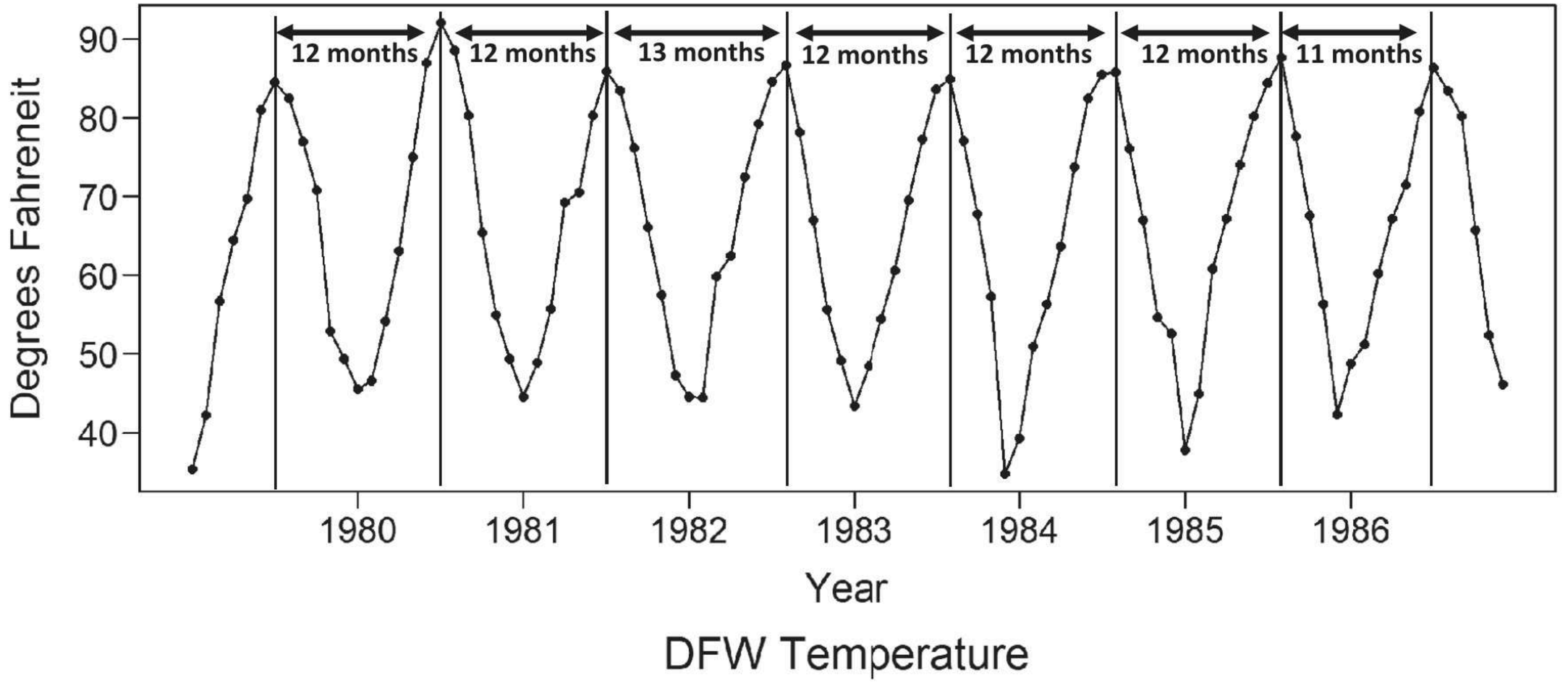

Monthly CO2 concentrations
CO2 concentratition
343
342
341
340
339
338
337
336
1980-01
1980-06
1980-11
1981-04
1981-09
Time

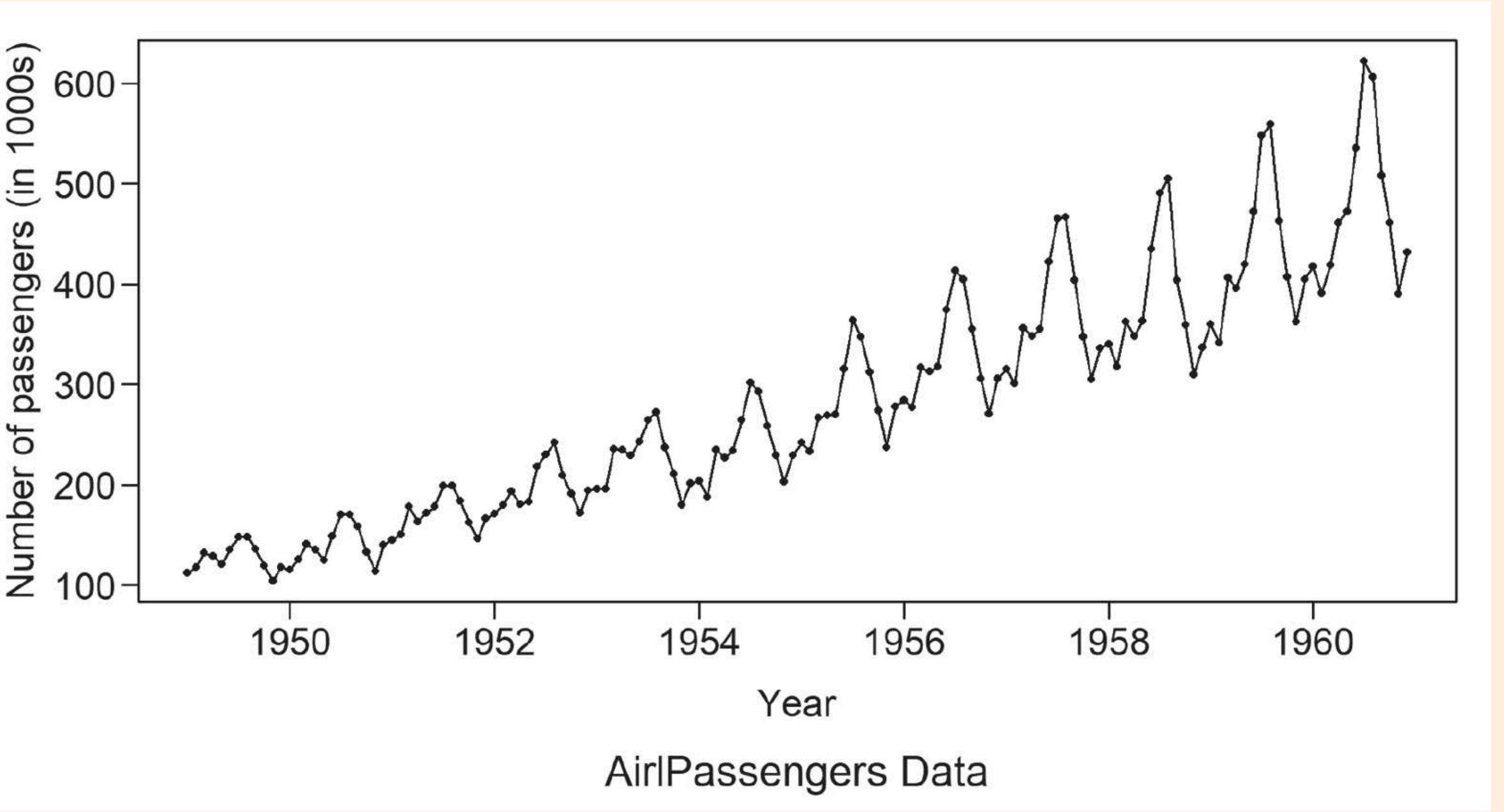
Seasonality

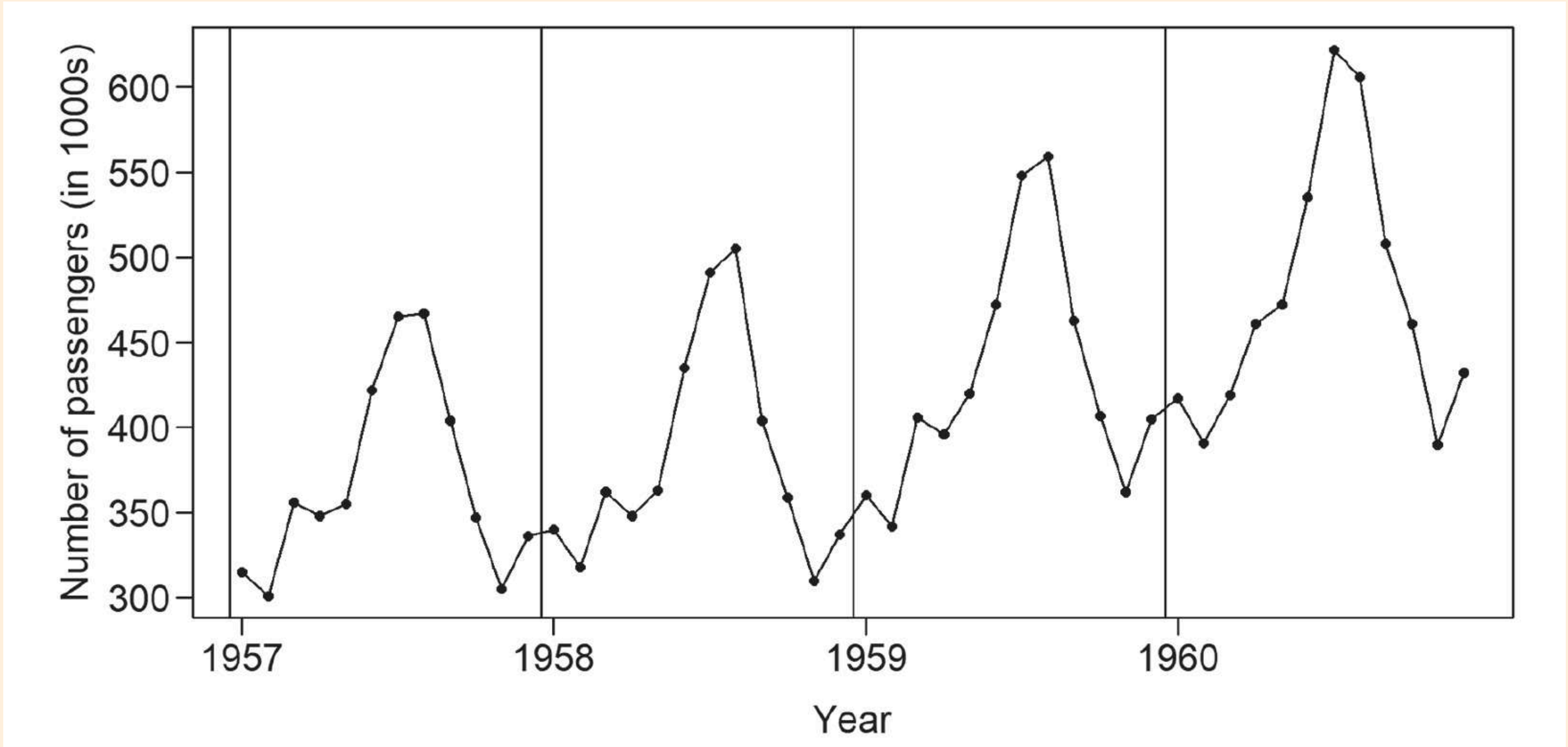


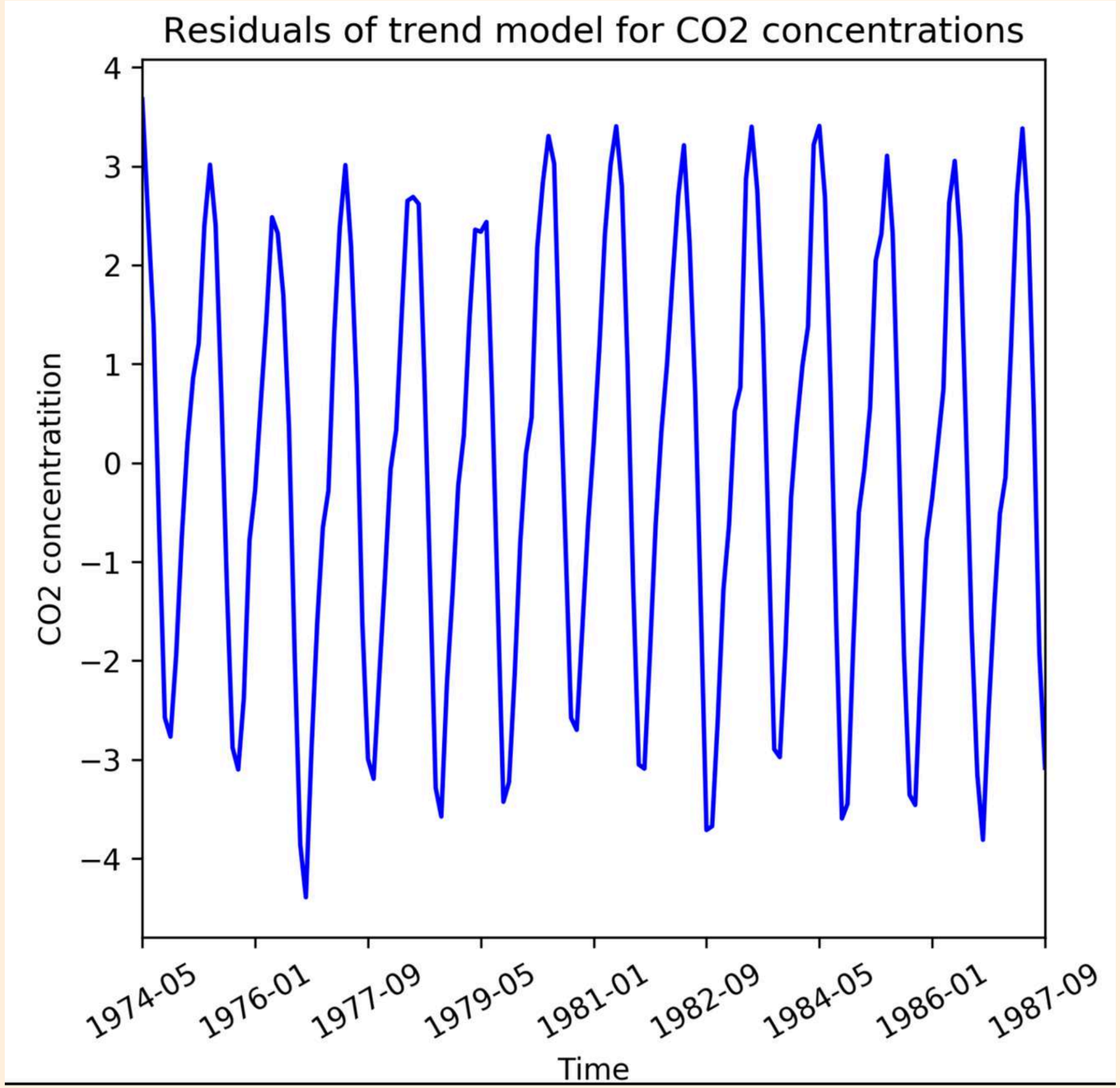


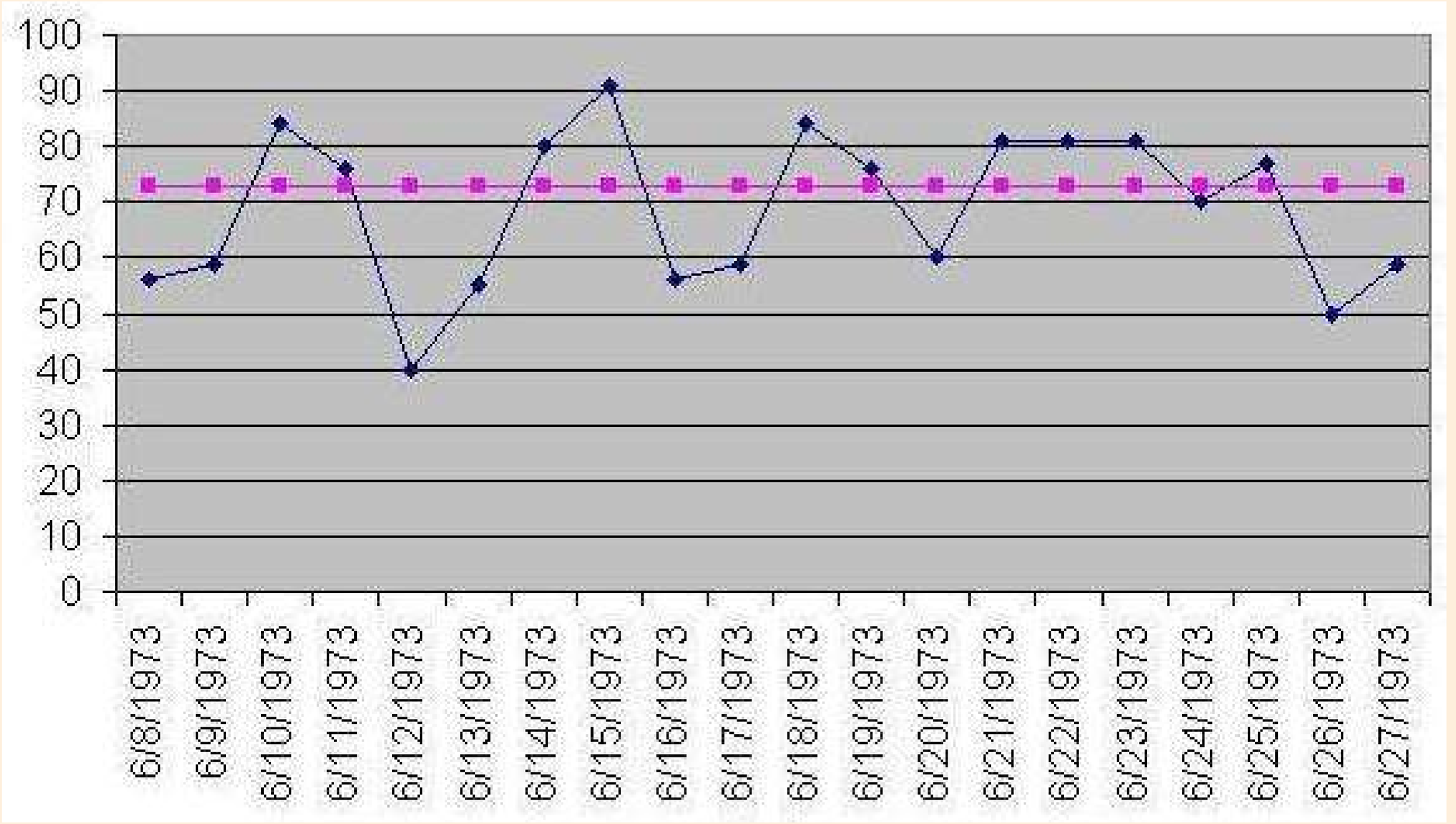
average monthly temperature for Dallas-Ft. Worth (DFW)

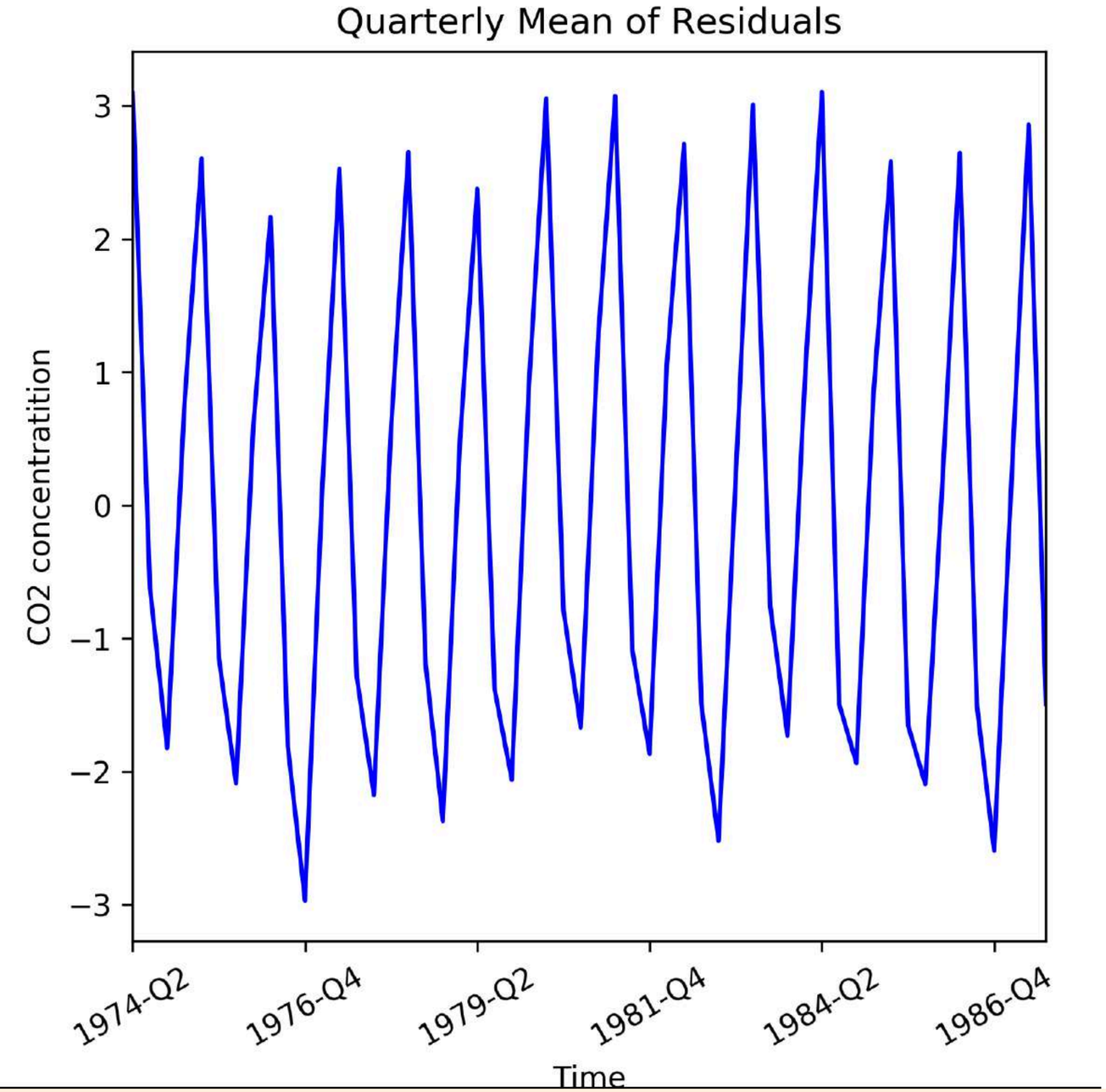

12 months
12 months
13 months
12 months
12 months
12 months
11 months
Degrees Fahrenheit
90
80
70
60
50
40
1980
1981
1982
1983
1984
1985
1986
Year
DFW Temperature

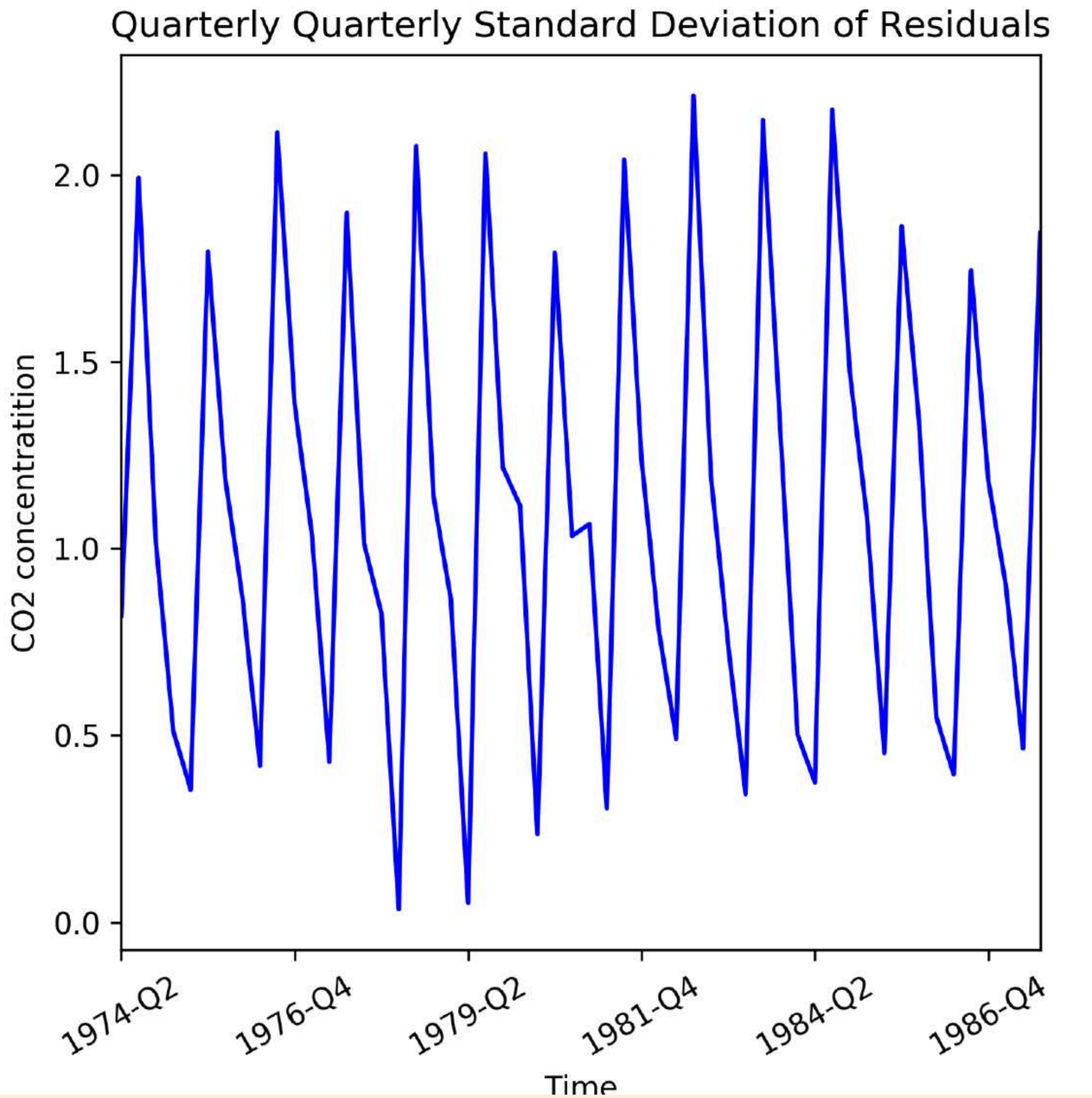

Number of passengers (in 1000s)
600
500
400
300
200
100
1950
1952
1954
1956
1958
1960
Year
AirlPassengers Data

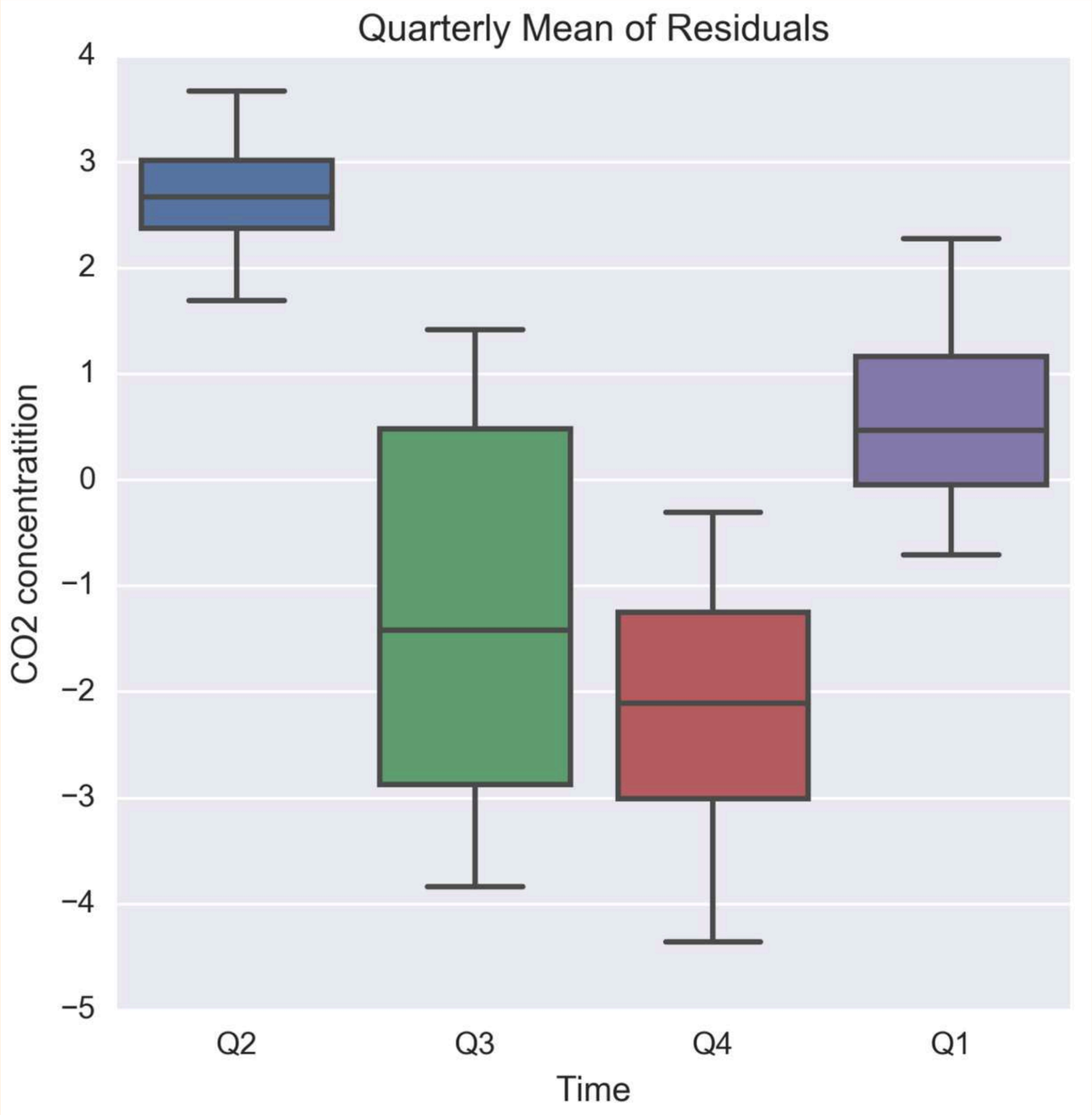

Number of passengers (in 1000s)
600
550
500
450
400
350
300
1957
1958
1959
1960
Year


Residuals of trend model for CO2 concentrations
CO2 concentratition
4
3
2
1
0
−1
−2
−3
−4
1974-05
1976-01
1977-09
1979-05
1981-01
1982-09
1984-05
1986-01
1987-09
Time


100
90
80
70
60
50
40
30
20
10
0
6/8/1973
6/9/1973
6/10/1973
6/11/1973
6/12/1973
6/13/1973
6/14/1973
6/15/1973
6/16/1973
6/17/1973
6/18/1973
6/19/1973
6/20/1973
6/21/1973
6/22/1973
6/23/1973
6/24/1973
6/25/1973
6/26/1973
6/27/1973


Quarterly Mean of Residuals
CO2 concentratition
3
2
1
0
−1
−2
−3
1974-Q2
1976-Q4
1979-Q2
1981-Q4
1984-Q2
1986-Q4
Time

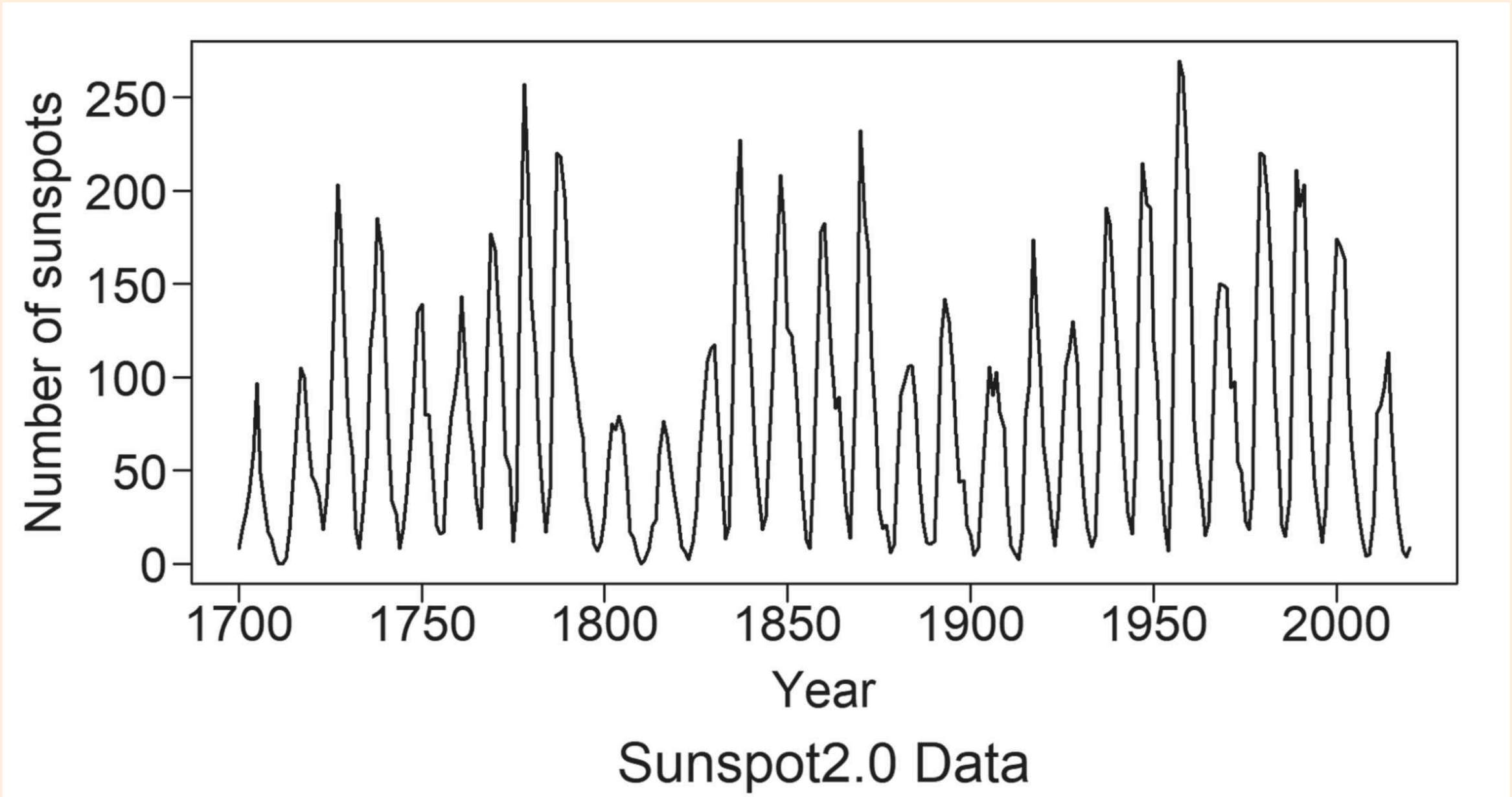

Quarterly Quarterly Standard Deviation of Residuals
CO2 concentratition
2.0
1.5
1.0
0.5
0.0
1974-Q2
1976-Q4
1979-Q2
1981-Q4
1984-Q2
1986-Q4
Time

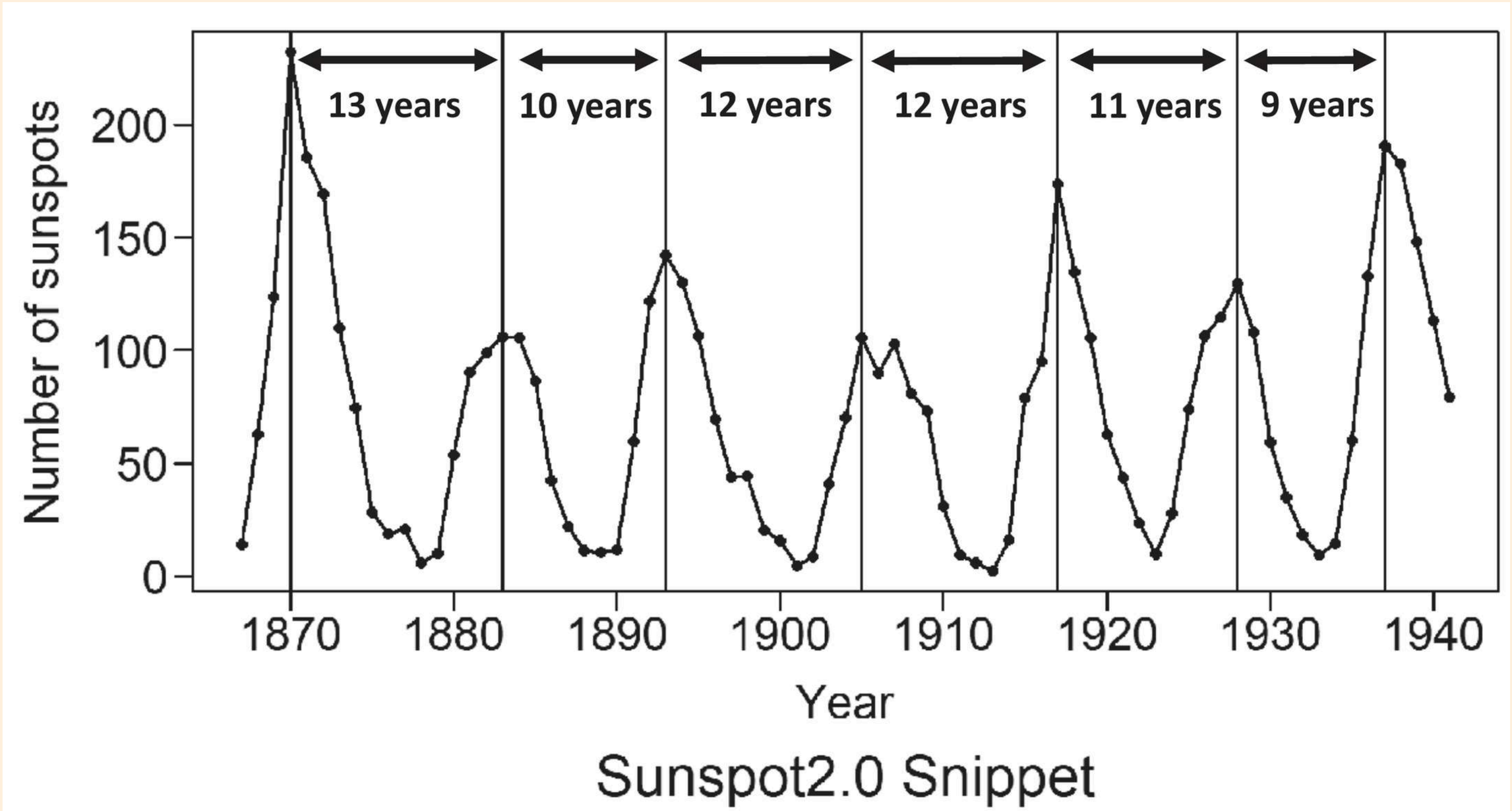

Quarterly Mean of Residuals
CO2 concentratition
4
3
2
1
0
−1
−2
−3
−4
−5
Q2
Q3
Q4
Q1
Time

Cyclical Data

Generalization of Seasonal Data

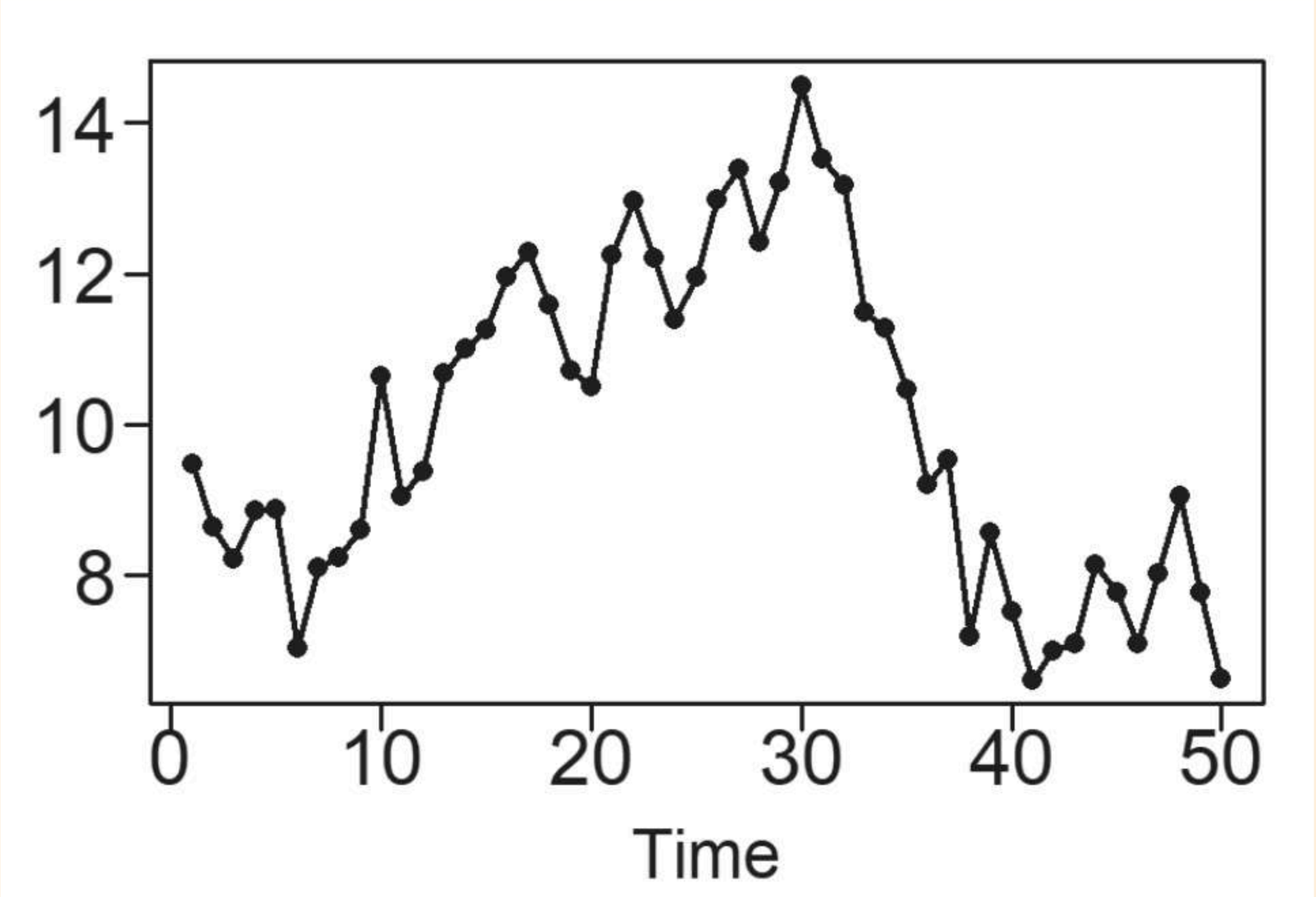
#3537


Number of sunspots
0
50
100
150
200
250
1700
1750
1800
1850
1900
1950
2000
Year
Sunspot2.0 Data

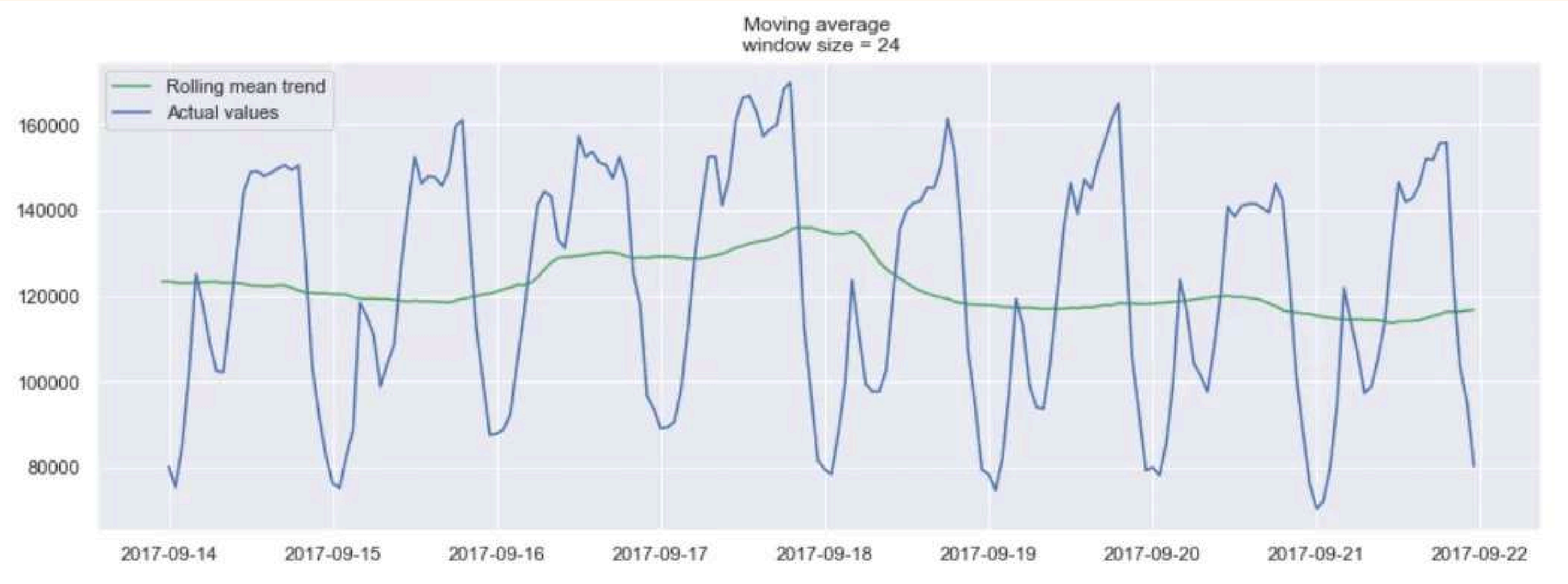


Sunspot2.0 Snippet

Random Variations



Smoothing


Moving average
window size = 24
Rolling mean trend
Actual values
160000
140000
120000
100000
80000
2017-09-14
2017-09-15
2017-09-16
2017-09-17
2017-09-18
2017-09-19
2017-09-20
2017-09-21
2017-09-22

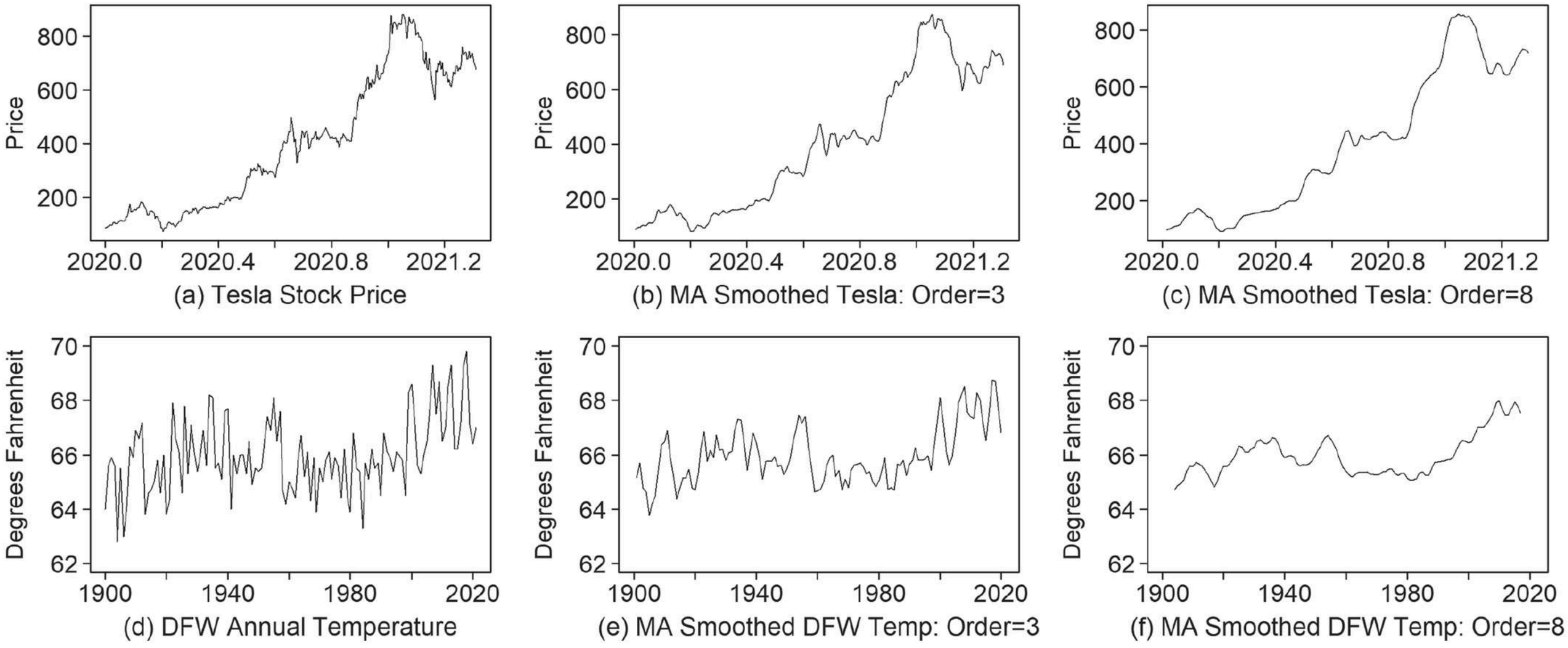


FIGURE 2.1 (a) Tesla stock prices, (b) and (c) data in (a) after applying 3rd- and 8th-order moving average smoothers, respectively. (d) DFW annual temperature data, (e) and (f) data in (d) after applying 3rd- and 8th-order moving average smoothers, respectively.

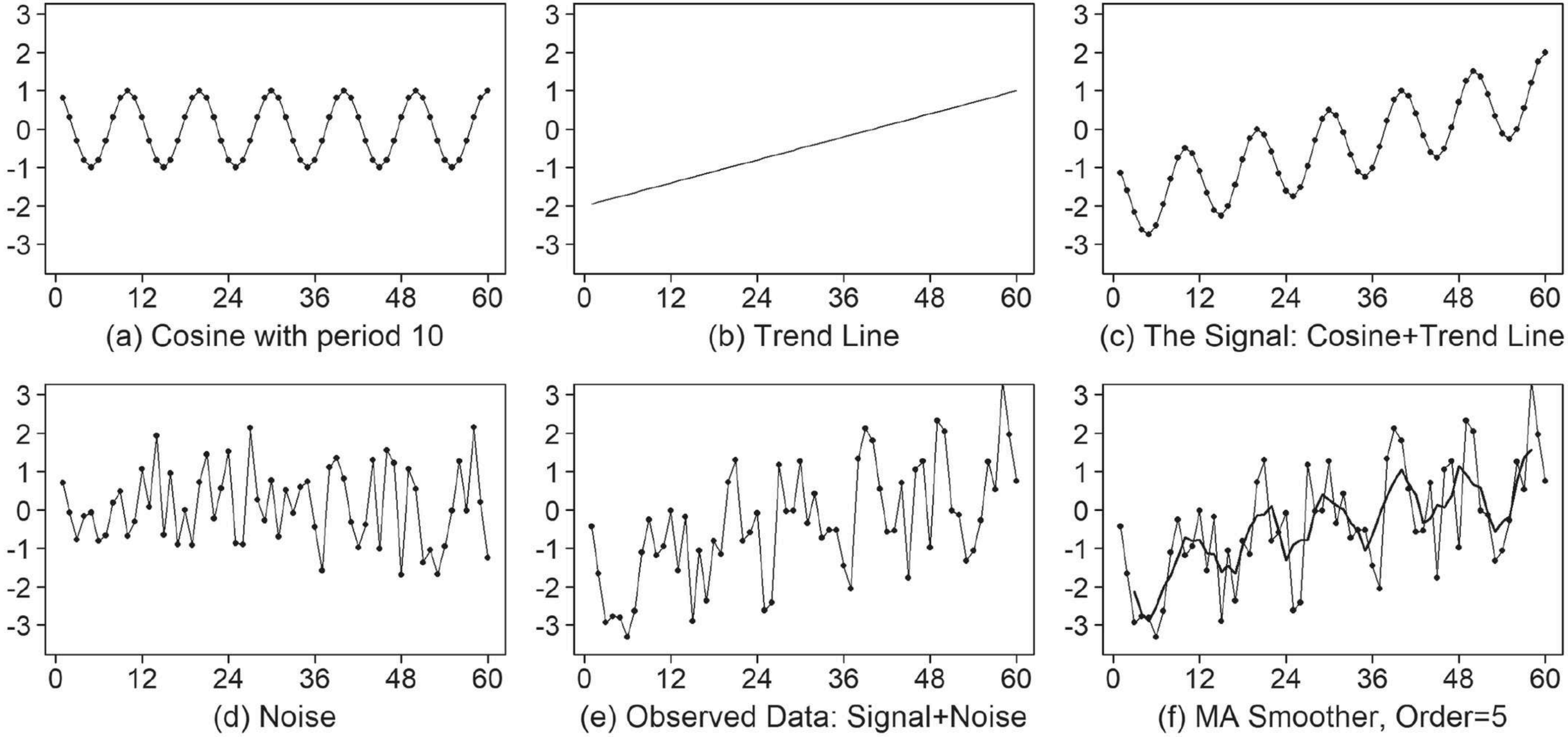


FIGURE 2.2 (a) Cosine curve with period 10, (b) the trend line, (c) cosine+line (the underlying signal), (d) the noise component, (e) signal+noise (the observed data), and (f) observed data in (e) with fifth order smoothing.

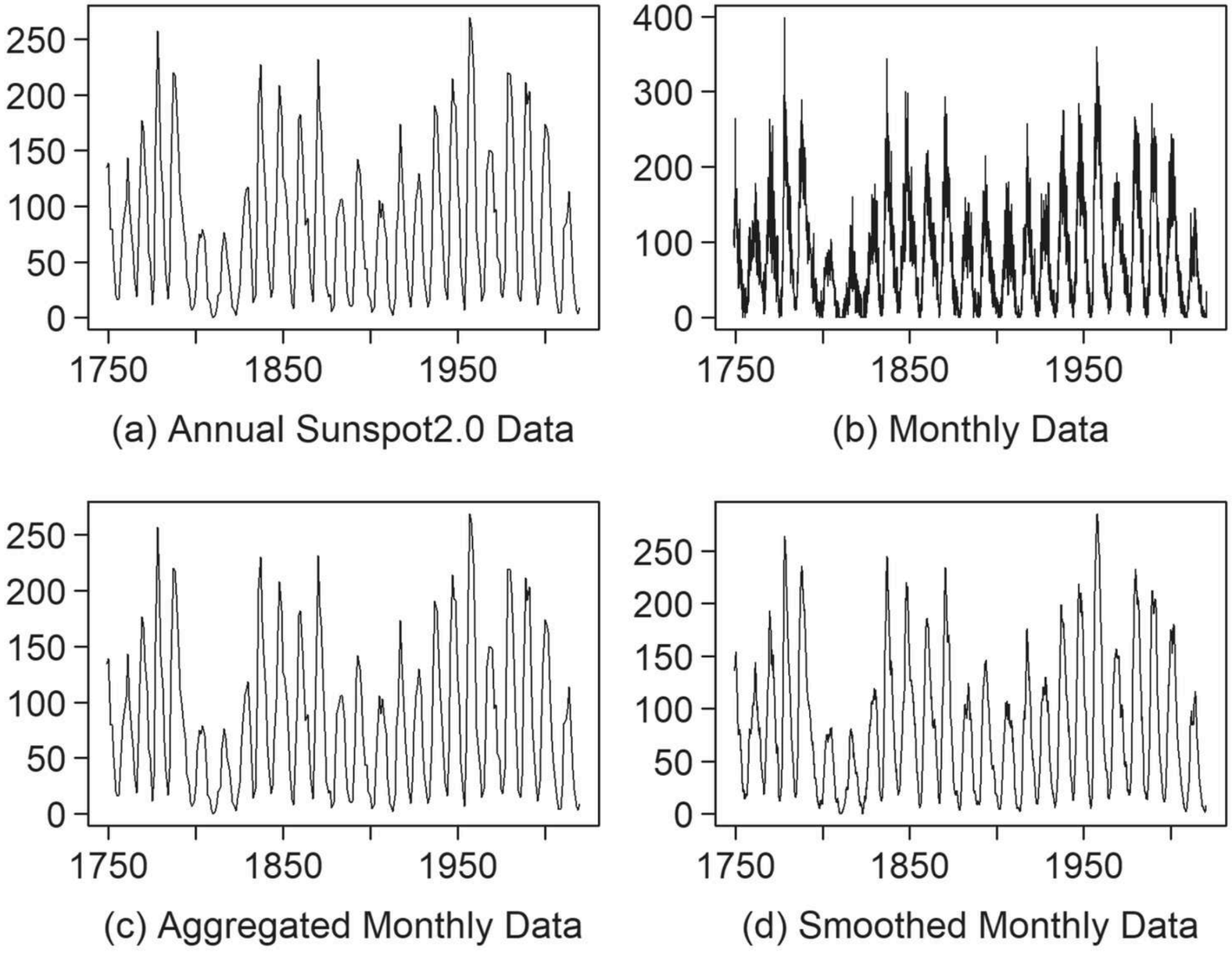


FIGURE 2.3 (a) Annual sunspot data for the years 1749–2020, (b) monthly data for the same time period, (c) annual data obtained by aggregating the monthly data, (d) smoothed monthly data using a 12th-order moving average smoother.

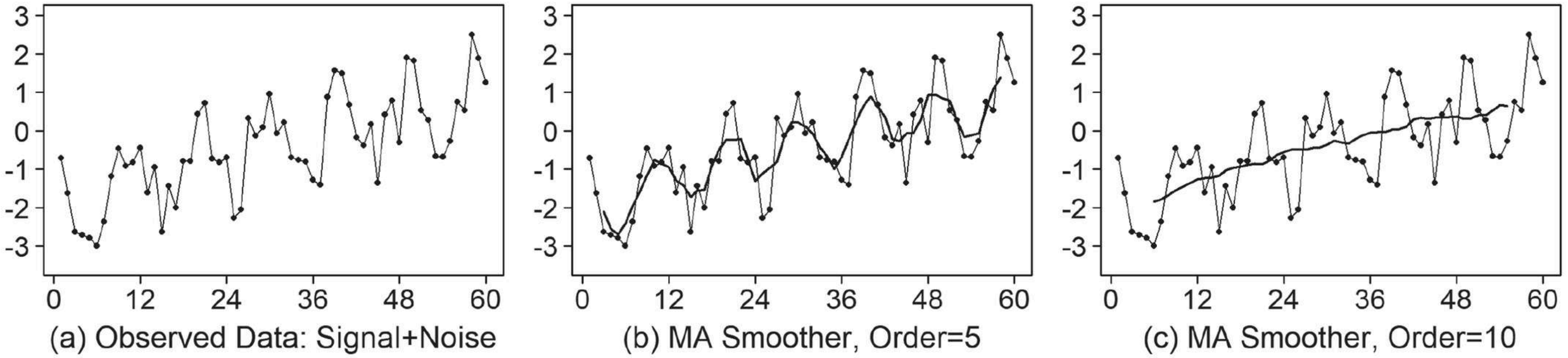


FIGURE 2.4 (a) Cosine+line+noise data, (b) and (c) observed data in (a) with 5th and 10th order smoothing, respectively.

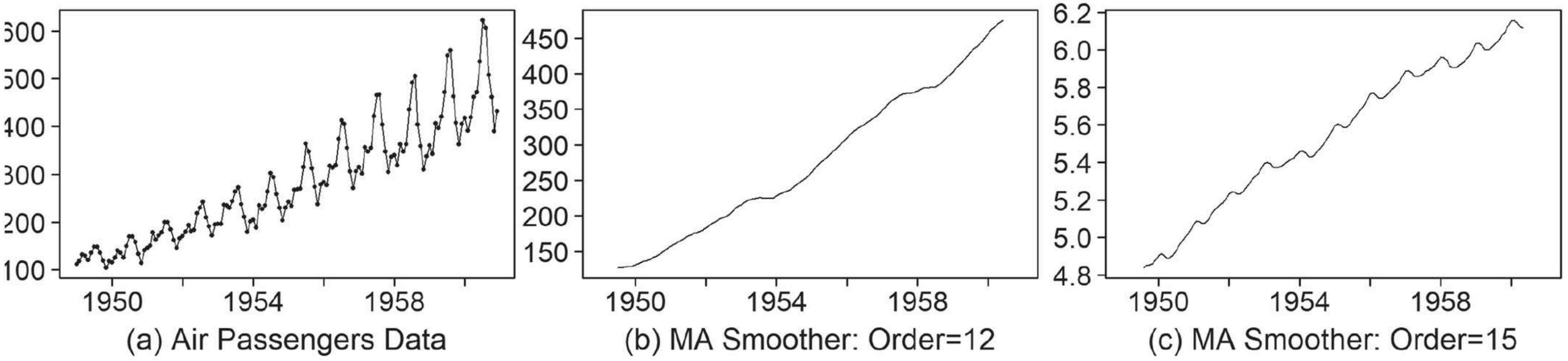


FIGURE 2.5 (a) Air Passengers data, (b) and (c) observed data in (a) with 12^{th} and 15^{th} -order smoothing, respectively.

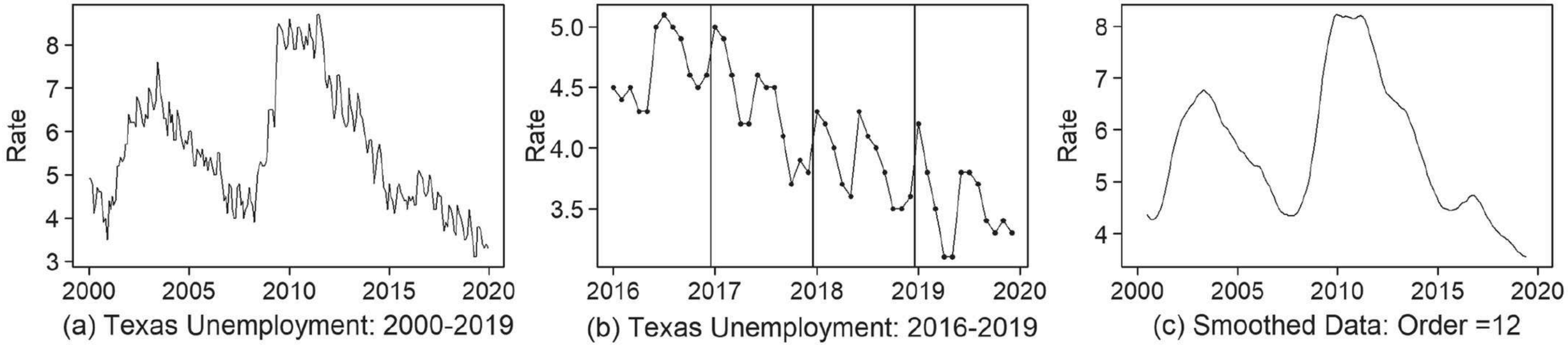
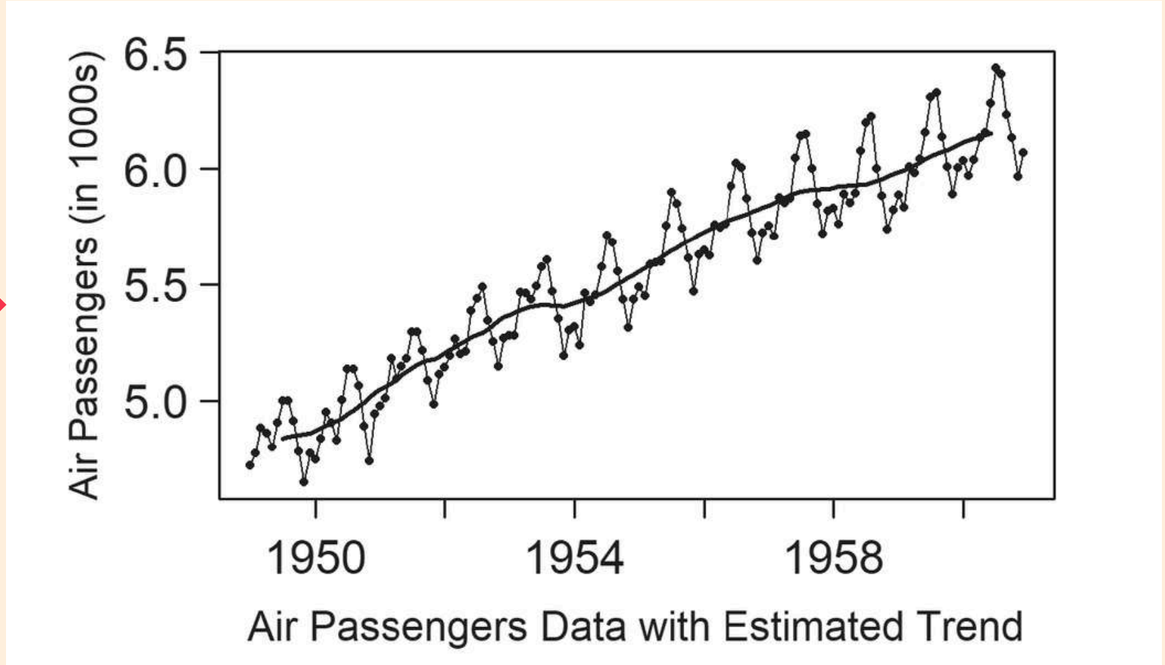
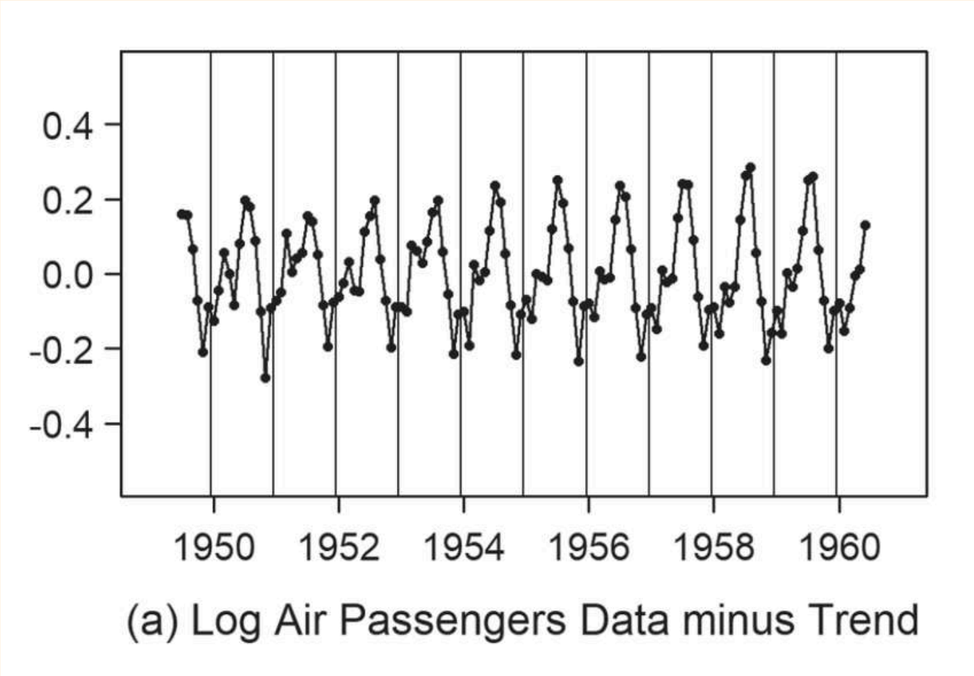


FIGURE 2.6 (a) Monthly Texas unemployment rates from 2000 through 2019 and (b) unemployment rates from 2016 through 2019, (c) original data after applying a 12th-order moving average smoother.

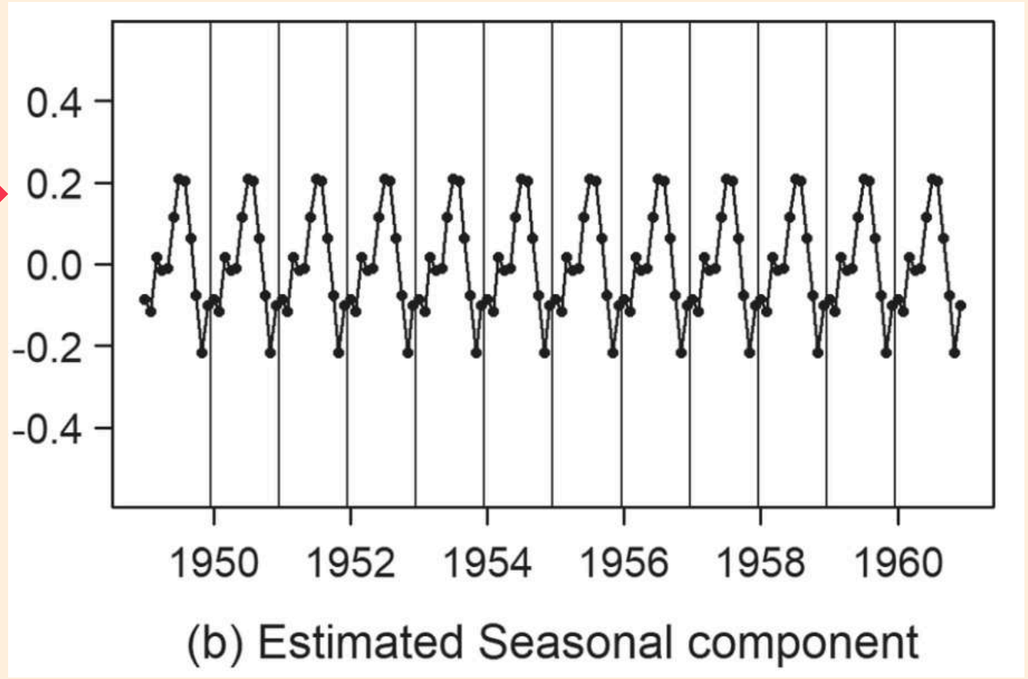
1


Air Passengers (in 1000s)
6.5
6.0
5.5
5.0
1950
1954
1958
Air Passengers Data with Estimated Trend

2

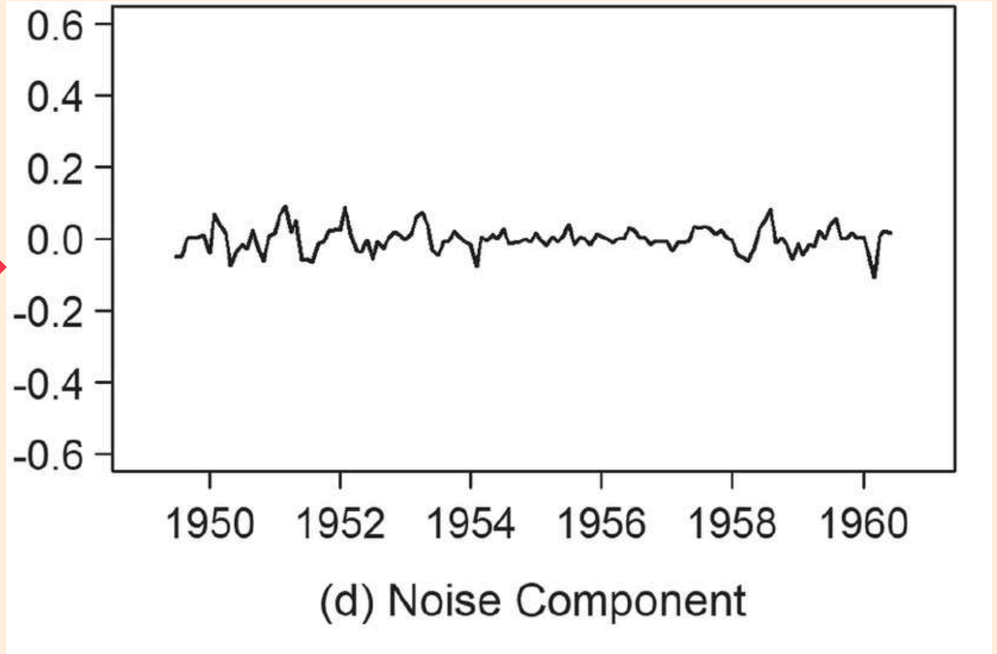

0.4
0.2
0.0
-0.2
-0.4
1950
1952
1954
1956
1958
1960
(a) Log Air Passengers Data minus Trend

3

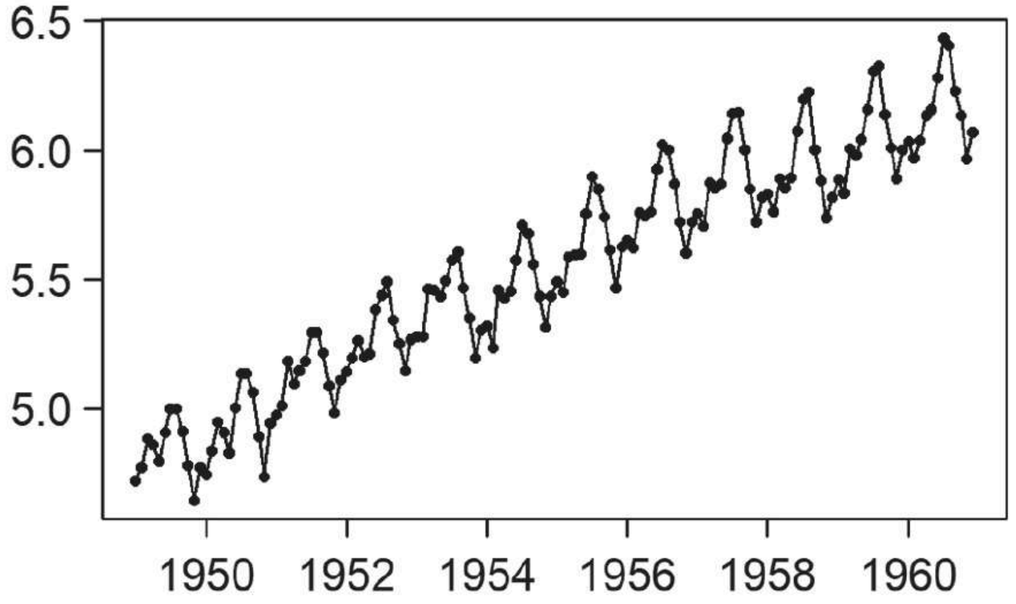


(b) Estimated Seasonal component

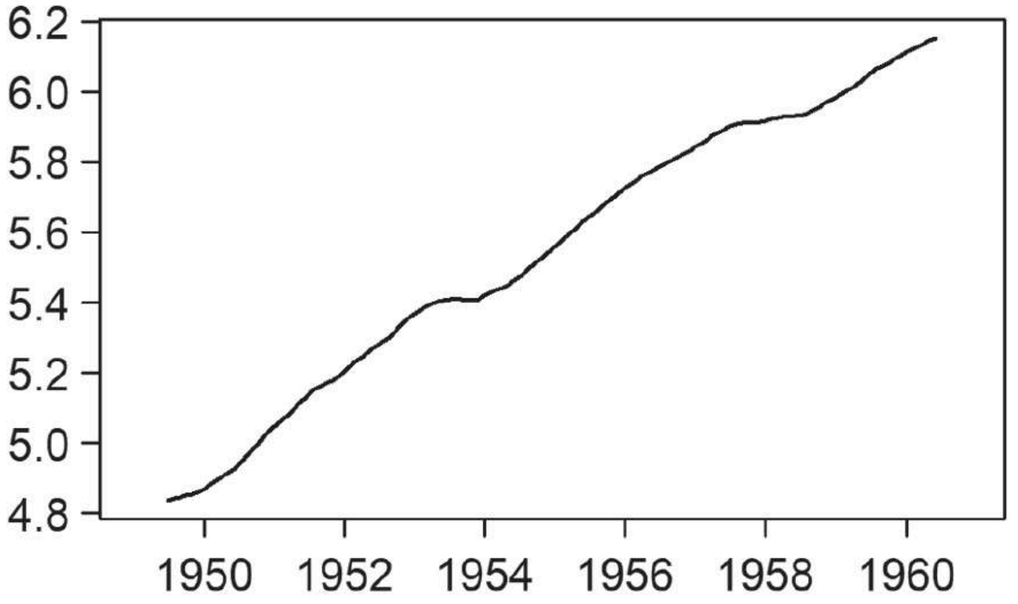
4



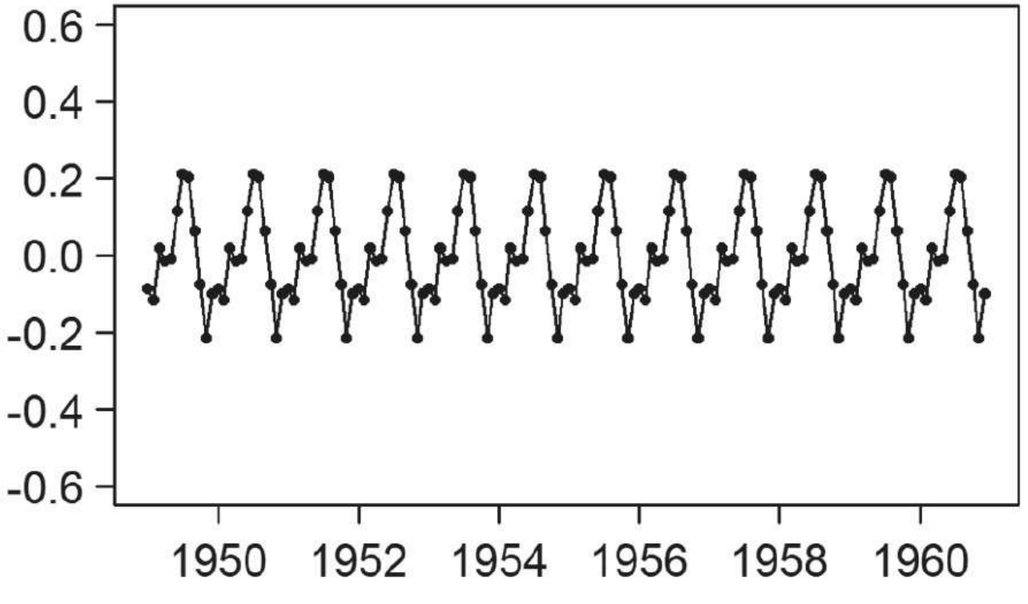
(d) Noise Component



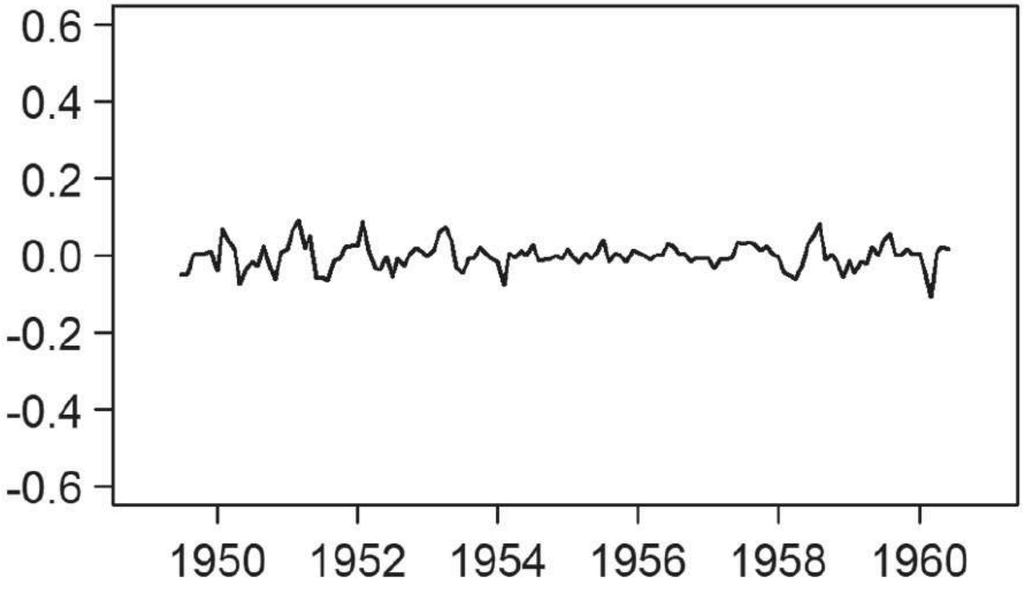
(a) Log Air Passengers Data



(b) Estimated Trend Component



(c) Estimated Seasonal Component



(d) Noise Component

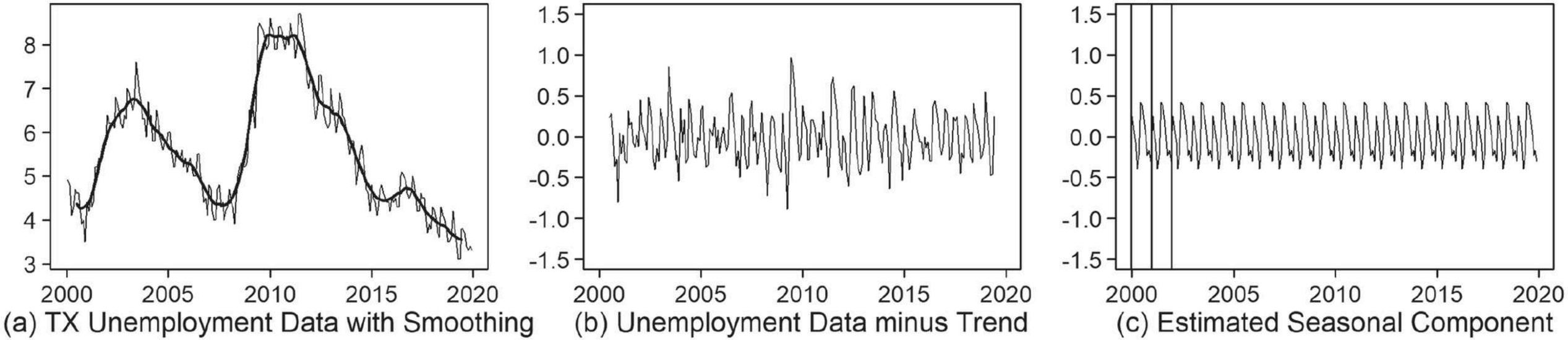
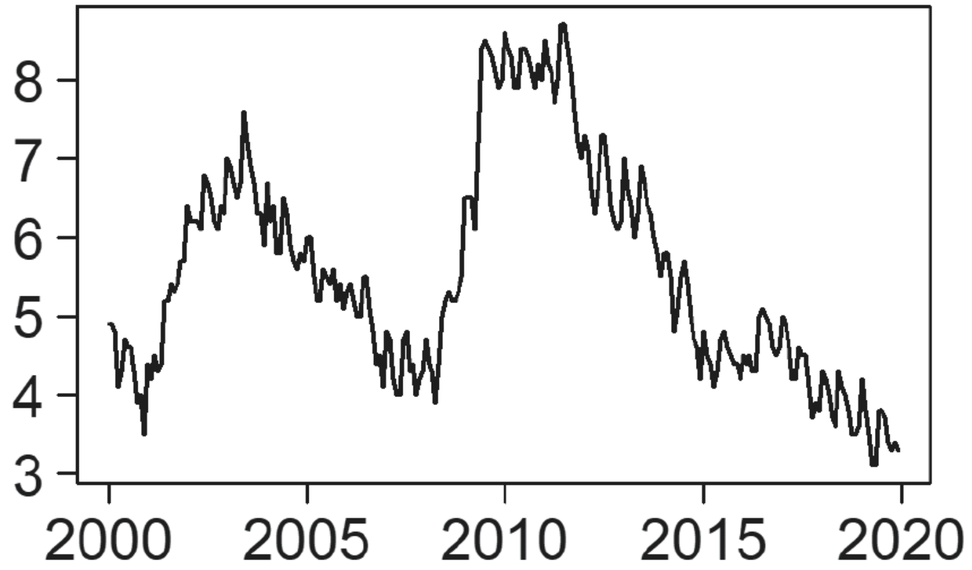
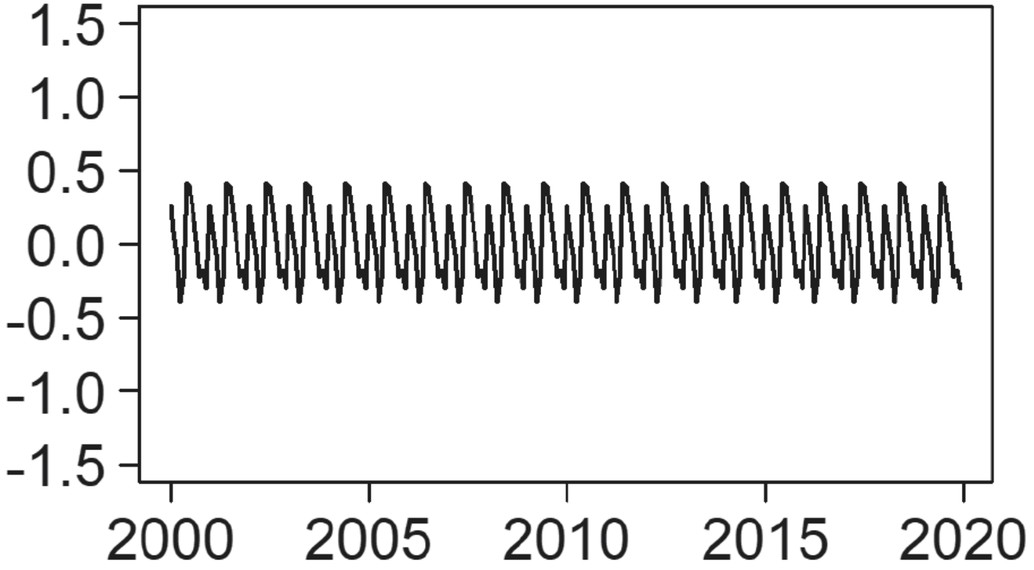


FIGURE 2.11 (a) Texas unemployment rates for 2000 through 2019 and showing moving average smoothed data of order 12, (b) Texas unemployment data minus trend, and (c) estimated seasonal component.

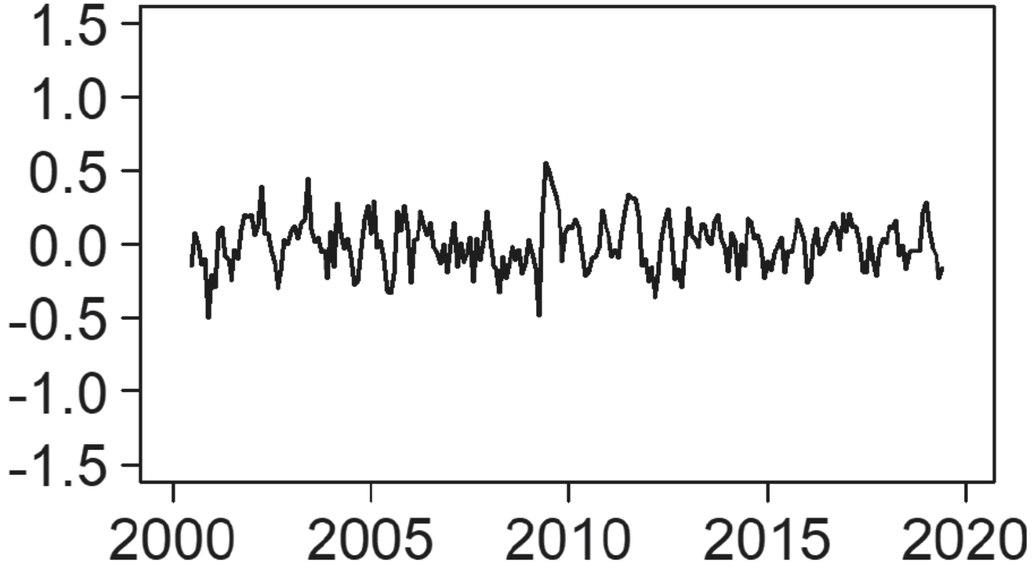


(a) Texas Unemployment Rates: 2000-2019

(b) Estimated Trend Component



(c) Estimated Seasonal Component



(d) Noise Component

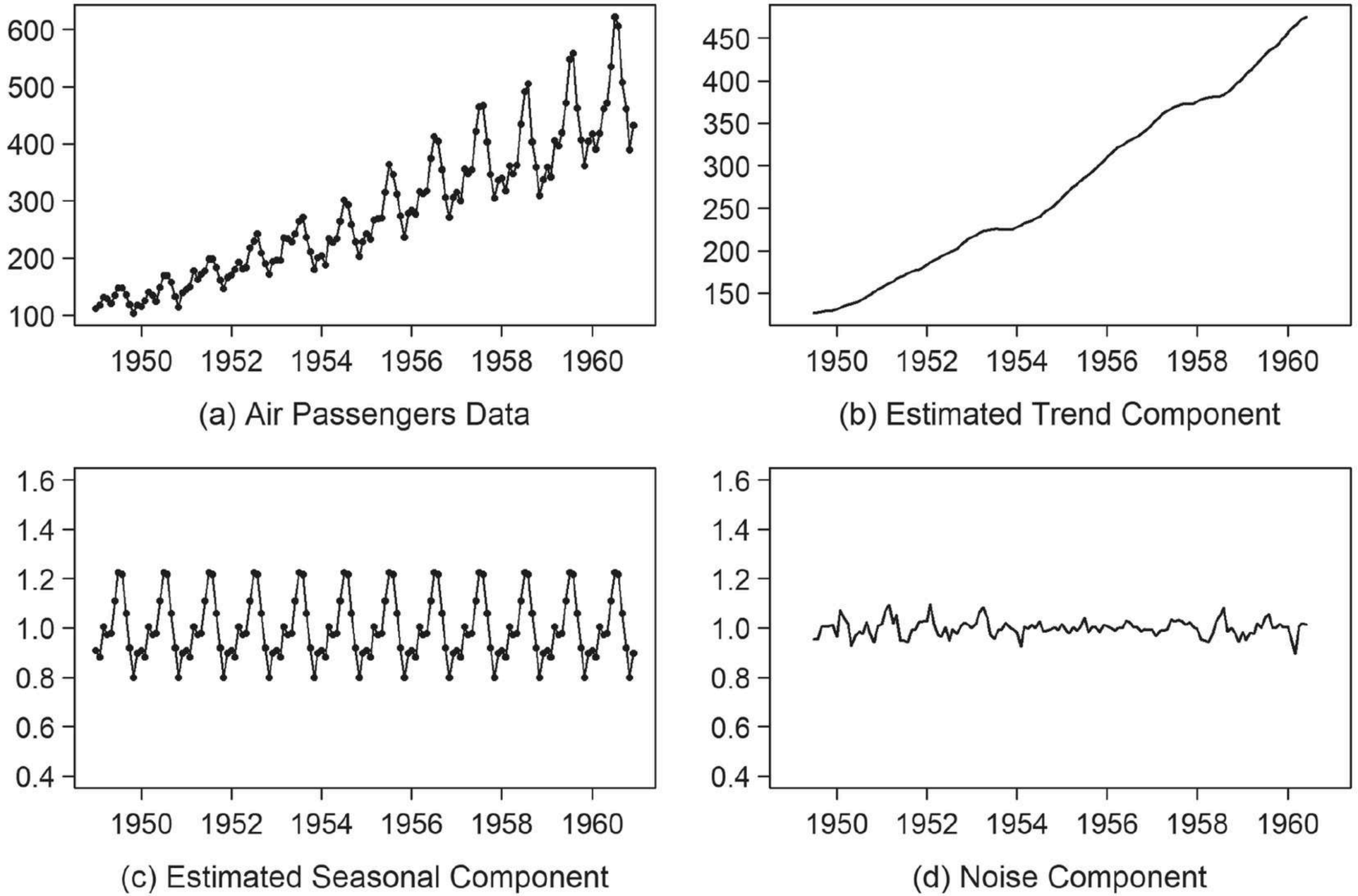


FIGURE 2.14 Multiplicative Decomposition of Air Passengers Data.

Seasonal Adjustment

Total Nonfarm | FRED | St. Louis Fed

Category: Current Employment Statistics (Establishment Survey) > Total Nonfarm, 5 economic data series, FRED: Download, graph, and track economic data.

stlouisfed.org

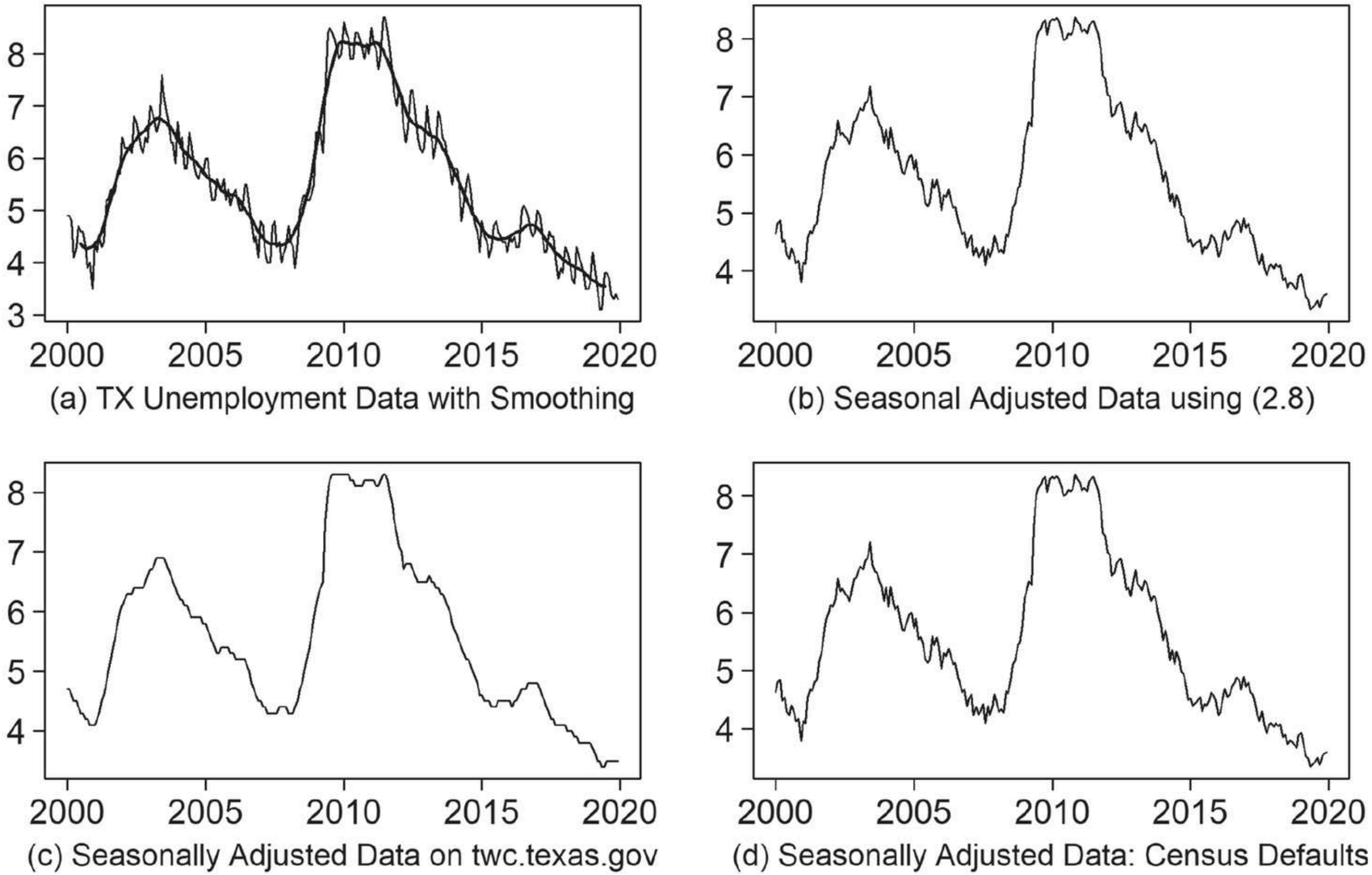


FIGURE 2.15 (a) Texas unadjusted unemployment data superimposed with the output from a 12th-order moving average smoother, (b) seasonally adjusted data using (2.8), (c) seasonally adjusted data from the twc.texas.gov website, and (d) seasonally adjusted data using the default options of the function seas.

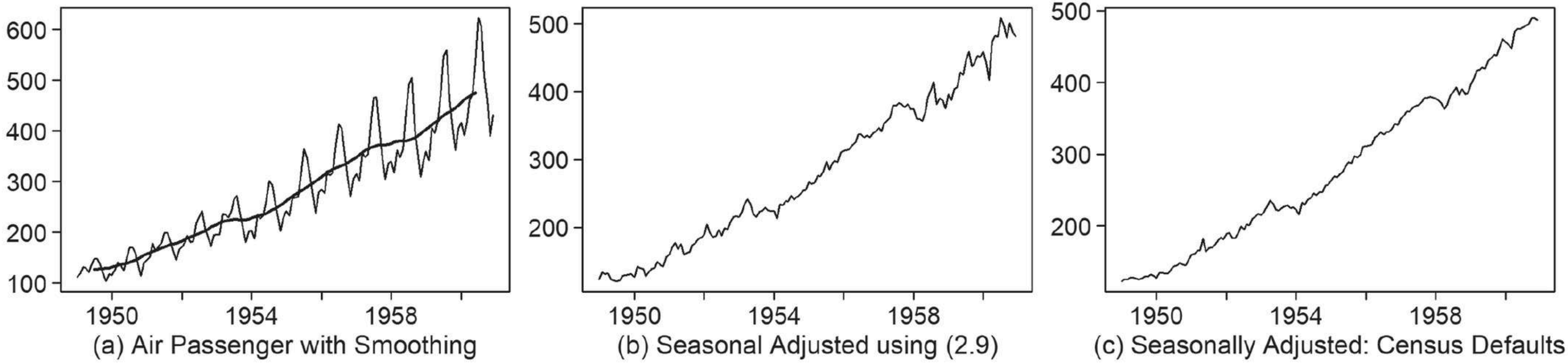


FIGURE 2.16 (a) Air Passengers data superimposed with the output from a 12^{th}-order moving average smoother, (b) seasonally adjusted data using (2.9), (c) seasonally adjusted data using the default options of the function seas in the CRAN package *seasonal*.

Exponential Smoothing

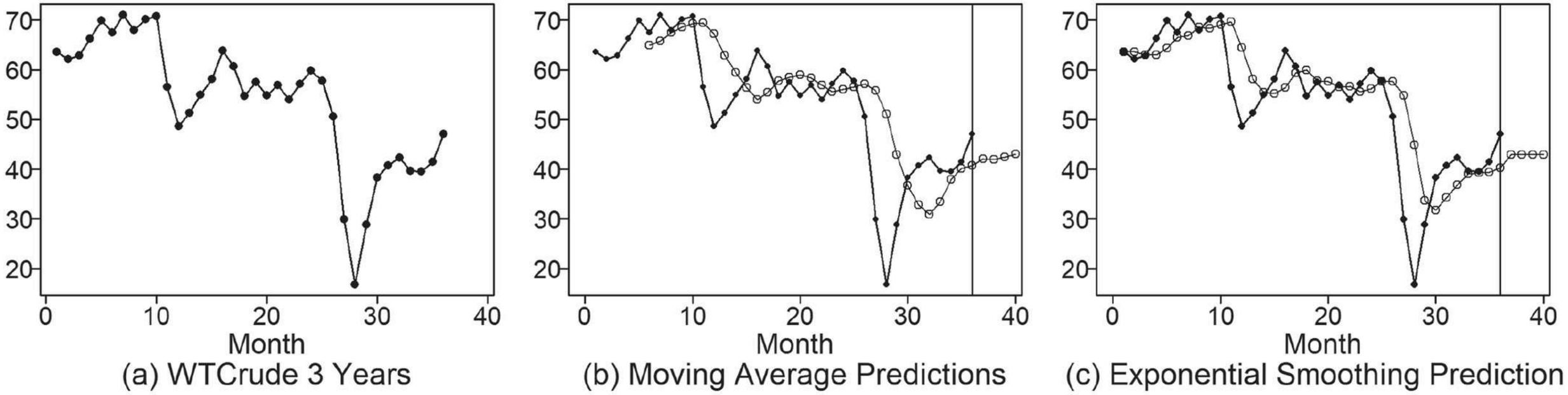
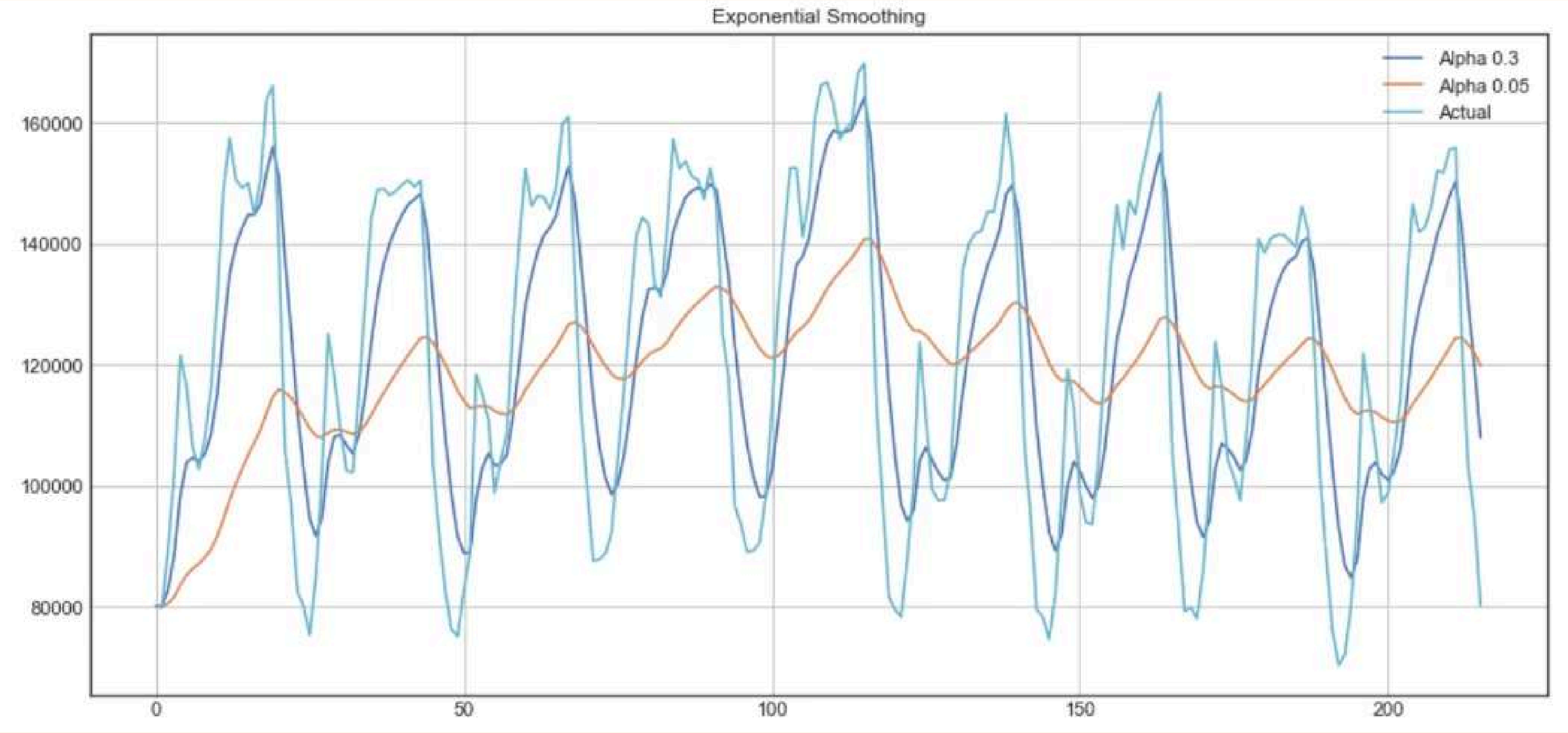
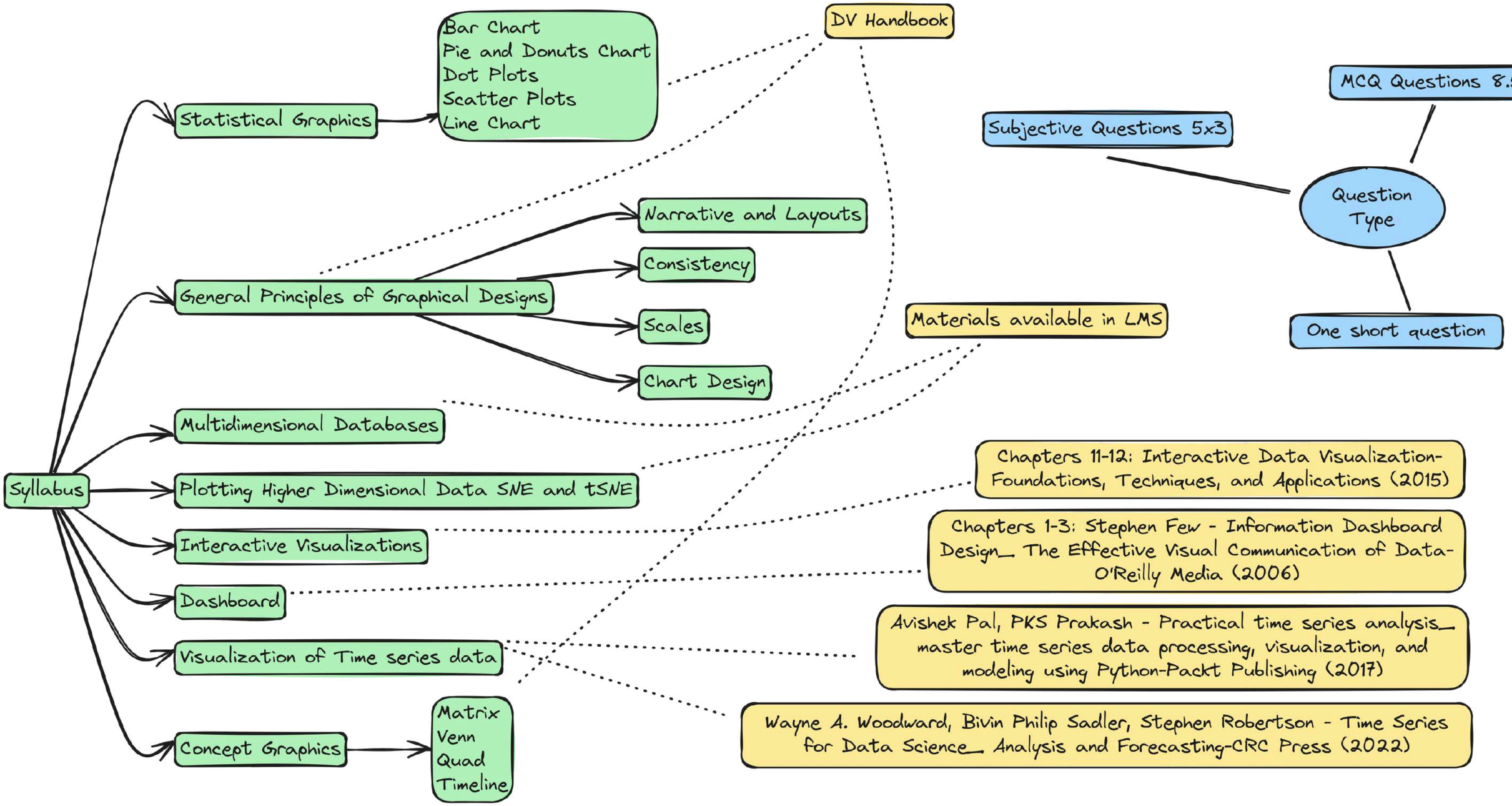


FIGURE 2.17 (a) Monthly price of West Texas Intermediate crude oil for the years 2018–2020, (b) crude oil prices along with 1-step ahead predictors using a 5th-order smoother, and (c) 1-step ahead predictions using exponential smoothing with $\alpha = .4$.


Exponential Smoothing
Alpha 0.3
Alpha 0.05
Actual
160000
140000
120000
100000
80000
0
50
100
150
200


Syllabus
Statistical Graphics
Bar Chart
Pie and Donuts Chart
Dot Plots
Scatter Plots
Line Chart
General Principles of Graphical Designs
Narrative and Layouts
Consistency
Scales
Chart Design
Multidimensional Databases
Plotting Higher Dimensional Data SNE and tSNE
Interactive Visualizations
Dashboard
Visualization of Time series data
Concept Graphics
Matrix
Venn
Quad
Timeline
DV Handbook
Materials available in LMS
Question Type
MCQ Questions 8.5 marks
Subjective Questions 5x3
One short question
Chapters 11-12: Interactive Data Visualization-Foundations, Techniques, and Applications (2015)
Chapters 1-3: Stephen Few - Information Dashboard Design_ The Effective Visual Communication of Data-O'Reilly Media (2006)
Avishek Pal, PKS Prakash - Practical time series analysis_ master time series data processing, visualization, and modeling using Python-Packt Publishing (2017)
Wayne A. Woodward, Bivin Philip Sadler, Stephen Robertson - Time Series for Data Science_ Analysis and Forecasting-CRC Press (2022)