

Chapter 2: Plotting Process Data

Knowledge Through Data

Sequence Plots

Analysis of Changes

Seasonality

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Do the data pertain to a particular point in time or do they record successive values of a variable over time?

Longitudinal and Cross-Sectional Data

Longitudinal data study the results from a process over time.

Examples: Monthly sales data, annual rainfall data, actual weights of individual “10 ounce” potato chips bags coming down the assembly line.

There is a first measurement, a second measurement, and so on.

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Knowledge Through Data

Types of Data: Continuous and Categorical

Continuous: Can potentially take any value on an interval of numbers.

Examples: cost, length, weight, temperature

Categorical: indicates the group or category to which an item belongs.

Examples: gender, hair color, marital status

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Data collected from a group of people or things at one point in time are called **cross-sectional** data.

Examples: Opinion polls, surveys in general, analysis of a warehouse full of microwave ovens

(A cross-section of people or things)

When the time dimension of longitudinal data is ignored, we will also say that we are looking at cross-sectional aspects of the data.

We look specifically at longitudinal aspects of data here. Cross-sectional analysis will begin in Chapter 3.

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Three Reason for Collecting Data:

- predicting future behavior
- detecting changes in a process
- sharing information (communication)

Examples:

Annual Los Angeles rainfall data

Edwin Moses' winning times in the 400-meter high hurdles

Chrysler Stock Price Data:
Daily 8/30/93 to 6/20/94

Sequence Plots

A **sequence plot** is a graph with time displayed on the horizontal axis and the corresponding variable from the process displayed on the vertical.

The sequence plot is an ideal tool for displaying process data. It helps in:

- predicting future behavior
- detecting changes in a process
- Sharing information (communication)

Notation: Let Y_t be the process variable of interest measured at time t .

Annual Rainfall (in inches) Los Angeles, 1878 - 1992

(Read across, row by row)								
20.86	17.41	18.65	5.53	10.74	14.14	40.29	10.53	16.72
16.02	20.82	33.26	12.69	12.84	18.72	21.96	7.51	12.55
11.80	14.28	4.83	8.69	11.30	11.96	13.12	14.77	11.88
19.19	21.46	15.30	13.74	23.92	4.89	17.85	9.78	17.17
23.21	16.67	23.29	8.45	17.49	8.82	11.18	19.85	15.27
6.25	8.11	8.94	18.56	18.63	8.69	8.32	13.02	18.93
10.72	18.76	14.67	14.49	18.24	17.97	27.16	12.06	20.26
31.28	7.40	22.57	17.45	12.78	16.22	4.13	7.59	10.63
7.38	14.33	24.95	4.08	13.69	11.89	13.62	13.24	17.49
6.23	9.57	5.83	15.37	12.31	7.98	26.81	12.91	23.66
7.58	26.32	16.54	9.26	6.54	17.45	16.69	10.70	11.01
14.97	30.57	17.00	26.33	10.92	14.41	34.04	8.90	8.92
18.00	9.11	11.57	4.56	6.49	15.07	22.65		

Edwin Moses' Winning Times

The data table below lists the times, in seconds, for Edwin Moses remarkable record of 122 successive wins in the 400-meter high hurdles race over the period from September 2, 1977 to May 29, 1987

(Read across, row by row)										
47.58	48.66	48.50	48.85	49.70	48.62	48.20	49.90	48.60	49.11	48.55
48.34	48.72	48.85	47.94	48.51	48.76	49.71	48.50	49.15	47.69	48.98
49.70	48.75	47.89	49.76	49.51	48.72	48.58	48.43	48.51	49.59	48.58
47.67	48.15	49.05	47.53	49.36	48.91	49.00	48.28	50.11	49.41	49.23
48.22	47.90	49.10	47.13	49.00	48.62	48.53	48.36	48.65	48.51	47.17
48.53	48.74	47.81	49.89	48.67	48.87	48.86	50.19	49.50	48.61	48.65
48.29	50.18	47.59	48.35	47.99	47.14	47.64	47.27	47.37	48.69	49.28
49.21	49.02	48.43	49.47	47.84	48.46	47.98	49.53	49.00	48.50	49.54
48.11	47.50	48.48	47.37	47.43	47.02	48.74	47.93	48.71	49.61	48.25
48.83	47.58	47.56	49.33	48.51	47.75	48.49	47.95	47.32	48.01	48.89
47.94	48.21	47.66	48.21	47.76	47.53	48.28	47.38	48.73	48.89	49.19
48.90										

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Economic Data and Analysis of Changes

Example: Chrysler Stock Price Data:
Daily 8/30/93 to 6/20/94

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Meandering

A *meandering series* is one in which observation that are close in time are also close in value but observation that are far apart in time may be very different in value.

Short term variation is small relative to long term variation. Long term variation may be quite large.

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Differences or Changes

For series that meander, the differences from time period to time period are usually most easily described, modelled, and predicted.

This is especially true for economic series such as prices and sales.

Difference at time t : $Y_t - Y_{t-1}$

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Example

Time	Index	Price	Difference or Change
8/30/93	1	43.250	*
8/31/93	2	42.750	-0.500
9/1/93	3	42.750	0.000
⋮	⋮	⋮	⋮

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Example

Time	Index	Price	Difference or Change	Percentage Change
8/30/93	1	43.250	*	*
8/31/93	2	42.750	-0.500	-1.15607
9/1/93	3	42.750	0.000	0.00000
⋮	⋮	⋮	⋮	⋮

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Percentage Changes

percentage change =

$$100 \left[\frac{\text{Current Value} - \text{Previous Value}}{\text{Previous Value}} \right]$$

Percentage change at time t:

$$100 \left[\frac{Y_t - Y_{t-1}}{Y_{t-1}} \right]$$

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Seasonality

Seasonality is a pattern that tends to repeat itself according to the period of a series.

period 12 for monthly data,
period 4 for quarterly data, and so on

Examples:

Retail sales tend to be large in December.
Beer sales peak in the hottest months.

Sequence plots using special plotting symbols help look for seasonality.

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Monthly Milk Production

Pounds of milk per cow for the United States, January, 1976, through July, 1993

(Read across, row by row)										
867	840	931	949	1007	978	946	918	870	872	836
880	899	845	964	979	1037	1003	976	948	897	900
860	899	915	851	968	982	1034	1005	975	945	897
906	864	901	923	862	981	989	1049	1023	997	971
929	936	895	935	958	926	1016	1023	1084	1050	1025
997	955	964	926	966	994	934	1062	1061	1110	1064
1044	1018	974	982	945	990	1008	943	1065	1059	1112
1074	1055	1031	992	1001	963	1007	1050	980	1099	1091
1154	1122	1103	1067	1023	1037	997	1034	1046	1008	1097
1094	1151	1104	1082	1055	1012	1024	986	1031	1057	981
1109	1113	1187	1147	1148	1129	1073	1089	1045	1080	1104
1022	1144	1147	1215	1168	1158	1133	1076	1086	1050	1094
1123	1052	1190	1191	1259	1208	1200	1173	1124	1148	1107
1158	1178	1135	1237	1230	1282	1227	1222	1196	1158	1179
1140	1193	1172	1130	1233	1222	1276	1225	1218	1186	1148
1165	1130	1186	1218	1141	1294	1274	1325	1263	1259	1232
1172	1202	1172	1225	1250	1169	1308	1296	1337	1261	1253
1238	1189	1226	1194	1256	1291	1238	1344	1314	1367	1321
1322	1295	1246	1278	1237	1292	1310	1216	1356	1344	1404
1354	1351									