

## Appendix


### Statistics for Quality: Control and Capability with Excel, JMP, Minitab, SPSS, CrunchIt!, R, and TI-83/-84 Calculators

In all cases, the software capable of making control charts requires the actual sample values. If you only have summary statistics (like  $\bar{x}$ ) for each sample, create the control chart as a connected scatterplot with the sample number on the  $x$  axis and the sample statistic on the  $y$  axis.

### Variable Control Charts and Capability



Excel does not have built-in capabilities to create control charts, but if you have a column with the statistic ( $\bar{x}$  or  $s$ ) and another with the sample numbers, you can create the basis for a control chart using **Insert** →

**Scatterplot with Straight Lines** . The sample number column (which should plot on the  $x$  axis) must be the left column in the two adjoining columns of data in the spreadsheet (use copy and paste if needed to make the columns adjacent to one another).

Capability can be calculated using NORM.DIST from the Statistical Functions menu.



Data must have one column for the sample values and a second column that indicates the sample number.

If your sample values are in separate columns, you will need to stack them and add a sample number identifier.

1. Click **Tables** → **Stack**.
2. Select the columns of data to be stacked into the box labeled “Stack Columns.” Enter an output table name and a name for the “Stacked Data Column.” The label column will indicate which column each value came from and will not be used. Make sure there is a check mark next to “Stack By Row.”
3. Click **OK**.
4. In the new data table, click the red triangle at the upper left and select **New Columns**.
5. Give the new column a name and use the drop-down to select **Sequence Data** for the “Initialize Data” option. Change the “To” box to the number of samples and the “Repeat each value N times” box to the number of observations in each sample.

Now create the control chart.

1. If you have the student version, click **Graph → Control Chart** and select “X-bar”; with the full version, click **Analyze → Quality and Process → Control Chart**.
2. Specify the process variable (the sample values) and the sample label variable.
3. Check the box(s) at the left for the type of chart (X-bar, S, or R).
4. If you are given process specifications (e.g.,  $\mu$  and/or  $\sigma$ ), click **Specify Stats** at the bottom of the dialog box and enter these.
5. Click **OK** for the chart.

For an individual and moving average chart, select the IR chart type. Click to select the variable of interest into the Process box and click **OK**.

To compute capability, click the red triangle next to “Variables Control Chart” at the top of the graph. Select **Capability**. Enter the lower limit, the target mean, and the upper limit.  $C_p$  and  $C_{pk}$  are given at the lower right of that output.

For more information and examples, see the JMP Video Technology Manuals videos X-Bar Charts, S Charts, and Capability Calculations.



1. Click **Stat → Control Charts → Variables Charts for Subgroups**, then select the type of chart desired.
2. Use the drop-down box to indicate if the observations for the samples are in a single column or across rows. Enter the process variable(s) in the main box. If all data values are in a single column, enter the sample identifier variable (or sample size) in the lower box.
3. If you are given process specifications (e.g.,  $\mu$  and/or  $\sigma$ ), click the button labeled “(chart type) Options” and enter these in the parameters tab dialog.
4. Click **OK**.

For a chart based on individuals, use **Stat → Control Charts → Variables Charts for Individuals → I-MR**.

1. In the dialog box, click to select and enter the variable name.
2. If you have process specifications, click **I-MR Options**. Enter the mean and standard deviation on the **Parameters** tab. Click **OK** to return to the main dialog.
3. Click **OK** for the chart.

To calculate capability, click **Stat → Quality Tools → Capability Analysis → Normal**.

1. Use the radio buttons to indicate if all the observations are in a single column or across rows.
2. Specify the columns.
3. Enter the values for the limits and mean and standard deviation (if applicable).
4. Click **OK**.  $C_p$  and  $C_{pk}$  are given at the lower right of that output.

For more information and examples, see the Minitab Video Technology Manuals, X-Bar Charts and S Charts.



1. Click **Analyze → Quality Control → Control Charts**. On the next menu, select “X-bar, R, s.” If your data have sample values across rows, select “Cases are Subgroups” as the data organization; if all measurements are in a single column, select “Cases are Units.” Click **Define**.

2. Specify the process measurement variables or the column with the sample values and the subgroups defined by (sample label) variable.
3. SPSS does not have the capability to specify a value of  $\sigma$  or  $\mu$ . Click the appropriate radio button to base the chart on the range or sample standard deviation.

Note that if you base the chart on the range, you have the option to also get an  $R$  chart; likewise, an option for the  $s$  chart if the  $X$ -bar chart is based on the sample standard deviation.

4. Click **Continue**.

To calculate capability, click **Statistics** in the main chart definition dialog. Enter the upper and lower specification limits (and the target, if applicable). Check the boxes for the appropriate statistics ( $C_p$  and/or  $C_{pk}$ ). Click **Continue** to return to the main dialog.

For more information and examples, see the SPSS Video Technology Manuals videos, X-Bar and S Charts and Capability Calculations.

### CRUNCH IT!

CrunchIt! does not have built-in capabilities to create control charts, but if you have a column with the statistic ( $\bar{x}$  or  $s$ ) and another with the sample numbers, you can create the basis for a control chart using **Graphics** → **Scatterplot**. Define the plot with the sample number as the  $X$  variable and the statistic as  $Y$ . Set the “Display” option to either “Line” or “Both.” Add the control limits by hand after printing the graph.

Capability can be calculated using the “Normal” option from the Distribution Calculator menu.



TI-83/-84

TI calculators do not have built-in capabilities to create control charts, but if you have a list with the statistic ( $\bar{x}$  or  $s$ ) and another with the sample numbers, you can create the basis for a control chart using a connected Scatterplot (▭) option from  $\text{2nd}$   $\text{Y=}$  (STAT PLOTS). Define the plot with the sample number as the  $X$  variable and the statistic as  $Y$ . The control limits can be calculated by hand and added to the graph using  $\text{Y=}$  functions (set  $Y$  variables equal to the CL, UCL, and LCL). Capability can be calculated using normalcdf from the DISTR menu.



You'll first have to install the qcc (quality control chart) package (this only needs to be done once). Click **Packages & Data** → **Package Installer** and locate qcc. Once the package has been installed on your computer, click **Packages & Data** → **Package Manager**, then locate TTR in the list and check the box labeled “Load” beside the package name. Note: You will have to load the package each time you use R when you want to do this type of analysis.

To produce charts, each sample group must be in its own row. If your data are not in that format, you can use function qccrow. Here are the steps:

```
> attach(dataset)
```

This makes referencing it easier:

```
> NV.by.rows <- qcc.groups(oldvar, sample-ind)
```

Here, NV.by.rows is the new variable with sample values across the rows, oldvar is the original process measurements, and sample-ind is the variable that details the sample numbers.

```
> qcc(nv.by.rows, type="xbar")
```

(or “S” or “R” for those charts.) For an individuals chart, type=“xbar.one”.

The moving range chart for individuals needs two columns in order to compute the moving range. With data in a variable called X in this example, use the following two commands:

```
> xmr.raw <- matrix(cbind(x[1:length(x)-1],
x[2:length(x)]), ncol=2)
> my.xmr.mr <- qcc(xmr.raw., type="R", plot = TRUE)
```

Computing capability requires the qualityTools package. Install and load it similarly to how qcc was installed and loaded. The basic command there is as follows:

```
> pcr (x, "normal", lsl=x.xx, usl = y.yy)
```

where x is a *single column* of process measurements, x.xx is the value of the lower specification level, and y.yy is the upper specification level.

For more information and an example, see the R Video Technology Manual, Control Charts.

## Attribute Control Charts (*P* and *C* Charts)



Data must have one column for the sample proportions and a second column with the sample size, if the sample size is not constant. The sample number is optional.

1. If you have the student version, click **Graph → Control Chart → P** (or **C**). If you have the full version, click **Analyze → Quality and Process → Control Chart → P** (or **C**).
2. Specify the process variable (the sample proportions or counts) and the sample size variable. If the sample size is constant, enter that in the box labeled “Constant size.”
3. Click **OK** for the chart.

For more information and an example, see the JMP Video Technology Manuals video, *P* Charts.



1. Click **Stat → Control Charts → Attributes Charts → P** (or **C**).
2. Enter the sample count variable in the main box. For the proportions chart, enter the sample size variable or a constant sample size in the lower box.
3. Click **OK**.

For more information and an example, see the Minitab Video Technology Manuals video, *P* Charts.



1. Click **Analyze → Quality control → Control Charts**. On the next menu, select **p, np**. Each row in the data file should represent one sample, so select “Cases are Subgroups.” Click **Define**. (Use “Cases are Units” if you have unsummarized data.)
2. Enter the count variable into the Number Nonconforming box and either a constant sample size or a variable containing that information in the Sample Size area.
3. Click **Continue**.

For more information and examples, see the SPSS Video Technology Manuals video, *P* Charts.



We assume the qcc package has been loaded; if not, click **Packages and Data** → **Package Manager**, locate qcc, and check the box to load it.

To produce charts, each sample group must be in its own row. With a count variable representing the sample outcome and another containing the sample size:

```
> attach(dataset)
```

This makes referencing it easier. The command example below creates a p chart. For a c chart, replace the “p” with “c.”

```
> Qcc(countvar, sizes=sizevar, type="p")
```

For more information and an example, see the R Video Technology Manual, Control Charts.