

USER GUIDE
PBCHARTS
SOFTWARE

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AND
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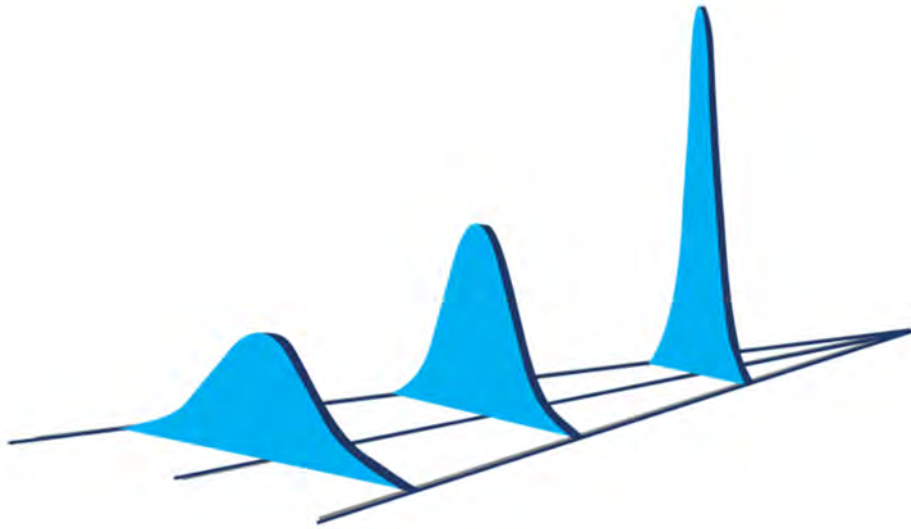
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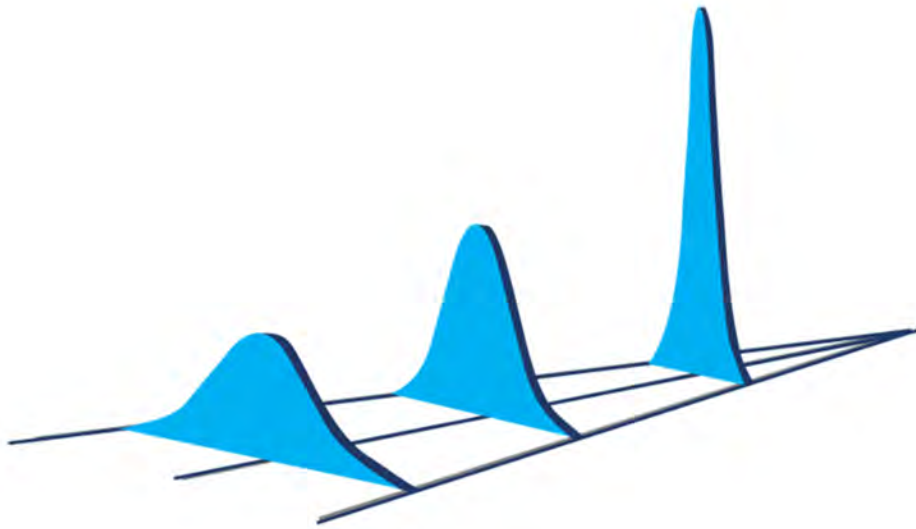
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INTRODUCTION

This book is an introduction to a software tool that quickly and easily creates Process Behavior Charts, a chart described in Donald Wheeler's Second Edition of *Understanding Variation: The Key to Managing Chaos*. It was published over 20 years ago and yet in that time, the "information age" he referenced has exploded beyond even his expectations.

Despite the exponential increase in digital technology, despite the speed with which one can be connected to networks to access, tally, and report data, we find ourselves still in a wasteland of misinformation, wasted time, and poorly drawn conclusions. We have increasingly easy access to any information we want, the moment we want it. We can hold worldwide meetings in the middle of the night. We are privy to what almost anyone thinks about almost anything – whether we want to know or not. But what has all this information gotten us? Have we gotten any smarter about interpreting what data means – or if it means anything at all?

Little seems to have changed in 20 years. As technology sits on the brink of real artificial intelligence, real human intelligence is stagnant. Whether in a manufacturing or business environment, leaders and managers find that although they have more numbers than ever before, they still do not know what these numbers mean.

If the numbers changed for the better compared to last month, then just wait – they will change for the worse soon enough. If the numbers changed for the worse compared to last month, then the apocalypse is at hand, and all are doomed! The boss is in despair. "Don't just stand there, do something! You have to have an explanation of why the numbers were so bad by 10:30 tomorrow morning."

More important, how are you going to keep these bad numbers from happening again? How are you going to get the workers to work harder?

"And Pharaoh said, 'You are lazy! You will be given no straw, but you must produce the same tally of bricks each day.'"

And so, it goes, month after month, world without end. From the dawn of time until the present, there is nothing new under the sun, just more of it.

The problem with our information age – true 20 years ago and still true now - was succinctly stated by Daniel Boorstin when he said:

“Information is random and miscellaneous, but knowledge is orderly and cumulative.”

Before information can be useful it must be analyzed, interpreted, and assimilated. In short, raw data must be digested before they can be useful.

This process of digesting data has been widely neglected at all levels of our educational system. Managers and workers, educators and students, accountants and businessmen, financial analysts and bankers, doctors, and nurses, and especially lawyers and journalists all have one thing in common. They come out of their educational experience knowing how to add, subtract, multiply, and divide, yet they have no understanding of how to digest numbers to extract the knowledge that may be locked up inside the data. In fact, this shortcoming is also seen, to a lesser extent, among engineers and scientists.

This deficiency has been called “numerical naiveté.” Numerical naiveté is not a failure with arithmetic, but it is instead a failure to know how to use the basic tools of arithmetic to understand data. Numerical naiveté is not addressed by the traditional courses in the primary or secondary schools, nor is it addressed by advanced courses in mathematics. This is why even highly educated individuals can be numerically naive. This software tool, PBCharts is the answer to numerical naiveté. PBCharts software is what has been missing for the last 20 years, allowing one to create charts quickly and easily.

The standard approach in business management is to define key performance indices, KPI's, that are key to both survival and growth. “If You Can't Measure It, You Can't Manage It” is the operating philosophy, so enormous attention is given to the critical KPIs. Today's KPI reports are presented as tables and/or dashboards often using stoplight color coding to highlight bad results, Red, and potential problems, Yellow, while Green is reserved for good results.

As an example, consider this Quarterly Report being reviewed at the Board of Directors meeting. The stoplight coding immediately identifies some serious discrepancies, the red coloring identifies poor results greater than minus 10% differences, the yellow indicates potential poor results greater than minus 5%. Green indicates good results greater than 10% which is also the stated plan, 10% above previous results. There are twelve red values, and ten yellow values representing 37% of the comparisons needing discussion.

4th Quarter Report 2019												
North Regions	4th Qtr 2019	3rd Qtr 2019	4th Qtr 2018	Quarterly Plan Value	% Diff from 3rd Qtr	% Diff from 2018	% Diff from Plan	Year-to-Date Values				2019 YTD as % Diff of 2018 YTD
								2019 Total	2018 Total	Plan	% Diff Plan	
North East	1148	976	952	1047	18	20.6	9.6	4185	3763	4139	1.1	11.2
North Central	702	743	670	737	-6	4.8	-4.7	2732	2223	2445	11.7	22.9
North West	806	688	878	966	17	-8.2	-16.5	3267	3609	3970	-17.7	-9.5
South Regions	4th Qtr 2019	3rd Qtr 2019	4th Qtr 2018	Quarterly Plan Value	% Diff from 3rd Qtr	% Diff from 2018	% Diff from Plan	Year-to-Date Values				2019 YTD as % Diff of 2018 YTD
								2019 Total	2018 Total	Plan	% Diff Plan	
South East	781	807	802	882	-3	-2.6	-11.5	3099	2917	3209	-3.4	6.2
South Central	359	447	462	508	-20	-22.3	-29.4	1680	1725	1898	-11.5	-2.6
South West	1337	1197	1196	1316	12	11.8	1.6	4867	5367	5904	-17.6	-9.3
Areas	4th Qtr 2019	3rd Qtr 2019	4th Qtr 2018	Quarterly Plan Value	% Diff from 3rd Qtr	% Diff from 2018	% Diff from Plan	Year-to-Date Values				This YTD as % Diff of Last YTD
								This Year Total	Last Year Total	Plan	% Diff Plan	
North	2656	2407	2500	2750	10	6.2	-3.4	10184	9595	10555	-3.5	6.1
South	2477	2451	2460	2706	1	0.7	-8.5	9646	10009	11010	-12.4	-3.6
East	1929	1783	1754	1929	8	10.0	0.0	7284	6680	7348	-0.9	9.0
Central	1061	1190	1132	1245	-11	-6.3	-14.8	4412	3948	4343	1.6	11.8
West	2143	1885	2074	2281	14	3.3	-6.1	8134	8976	9874	-17.6	-9.4
Total	5133	4858	4960	5456	6	3.5	-5.9	19830	19604	21564	-8.0	1.2
Represents good values greater than 10%												
Represents potential problem areas with values between minus 5 and minus 10%												
Represents bad values larger than minus 10%												

While all the red highlighted numbers are accurately calculated and true, they by themselves give entirely the wrong picture of the actual reality. They are in fact false signals of actual problems. Process Behavior Charts put all the data into its proper context.

Using a dashboard of Process Behavior Charts, none of the six regions show a departure from their usual behavior. They show Regions that were growing have recently flattened, A region that is in drastic decline, and even someone gaming the system as The North East Territory seems to do repeatedly every few years finishing the year with a big quarter, no doubt to win a big award.



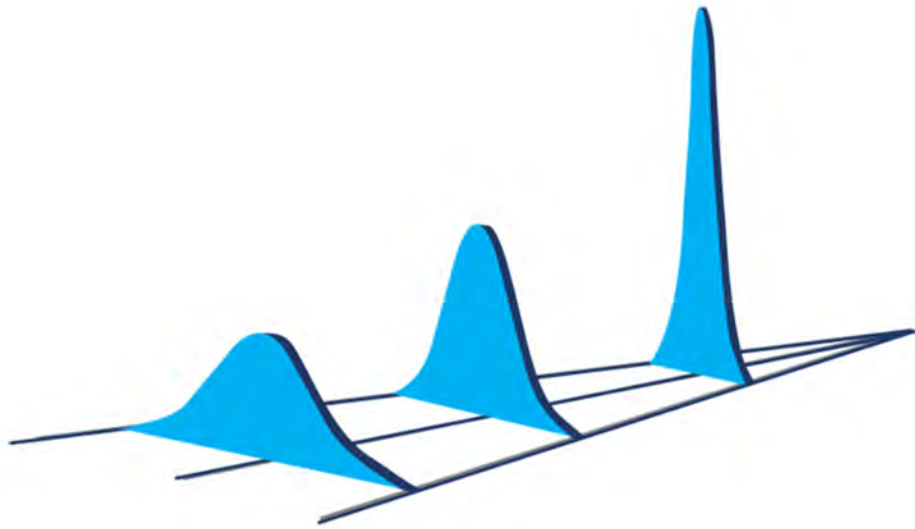
Looking at tables of numbers often promotes just one question “What happened?” The Process Behavior Charting method asks an additional question, “What is happening?” Knowing which question to ask in response to data is fundamental to knowing the method for improvement. The two questions – which sound similar but are asking quite different things – require us to define the underlying variation in the numbers we see; knowing that is the key to making lasting improvements.

Regardless of the process, improvement is always desirable. Ask anyone: business managers, clergymen, heads of not-for-profit organizations, or the kids running the neighborhood lemonade stand. They all want improvement, in meeting the needs of the customer, in fulfilling the demands of the shareholders, or increasing the welfare of those being served.

By taking on the mindset and methodology of statistical thinking, understanding variation, and how to identify the signals amidst the noise, we can better manage and improve

processes. The questions our leaders ask drives a lot of activity. When statistical thinking is employed, better questions are asked and the right direction for that activity is easier to find.

The use of the techniques presented in this book can have profound consequences both for individuals and for organizations. These techniques have been thoroughly proven in almost 100 years of practice in all walks of life. However, until these techniques are put into use nothing will happen. Numerical naiveté can only be overcome through practice. The right questions are only asked through statistical thinking. This book will tell you how to go about doing both. The real world will give you the opportunities for practice.



ACKNOWLEDGMENTS BY MICHAEL MERCER

I met Donald Wheeler in the early 1990's at a 3M Company sponsored Statistical Practitioners Conference organized by Peter Peterka. Both Peter and I became passionate advocates for Dr. Wheeler's methods.

I joined a 3M special interest group with fellow minded others to promote the use of process behavior charts. I was obsessed with creating a tool to make process behavior charts. I worked nights at home and created a Minitab Macro to produce process behavior charts. Subsequently the special interest group ported my Minitab Macro to an Excel Macro because it was the predominant software in use at 3M. The macro is still used in the 3M Company today.

I have been working with the two precursor software packages developed for over twenty-five years, so I am exceptionally happy to be part of the development of software ready to share with the world. Luckily, Peter found a willing collaborator in Jon Peltier, who wrote the code.

I would like to thank the following people who helped me create my Minitab-based process behavior chart application: Peter Peterka and Pete Jacobs, who organized the conference. Stan Lindell, Tape Manufacturing Division Quality Manager, who encouraged me to use Minitab Macros. Rich Mills, Business Development Team leader, and Steve Shields, Tape Business Cost Accountant, who used Process Behavior Charts to report their business key performance indices. John Ditlefsen, New Ulm Plant Manager, who ran his 3M plant weekly staff meeting using process behavior charts. Terry Ziemer, Chief Minitab Macro Developer, for help in macro programming. And finally, Bill Rolfes, who created the first Excel Macro at 3M still being used to produce process behavior charts.

November 2021

ACKNOWLEDGMENTS BY PETER PETERKA

Dr. Wheeler has created a basis of thinking which I witnessed first-hand. I was fortunate I had a senior executive at 3M, Keith Moe, who was a believer of the value of Process Behavior Charts. Thanks to him, I saw firsthand when a business leader asked questions, people wanted to have answers – so it's vital that the leader is asking the right questions. Keith wanted to see Process Behavior Charts in addition to traditional accounting tables. His drive influenced other executives to focus on understanding and improving their businesses, rather than explaining the difference between quarterly reports. He told us more than once, "The biggest room in the world is the room for improvement."

I'd like to thank another 3Mer, Andy Kirsch, who led the team that promoted the use of Dr. Wheeler's method throughout the company. It was through his efforts that the use of these methods became a common practice at 3M lasting until this day.

Over the past twenty years I have made many attempts to create an easy-to-use tool to help people implement Process Behavior thinking. I am very thankful and fortunate to have partnered with Jon Peltier and Mike Mercer in creating such a tool, which I call PBCharts, in honor of Dr. Wheeler. I would also like to thank Donald Wheeler allowing us to use his Sellit data in Chapter 9.

We are just getting started.

November 2021

PROLOG

Are you anxious to see what this software can do? It produces Process Behavior Charts which is the name that Dr. Donald Wheeler uses to describe Statistical Process Control Charts.

Statistical Process Control was invented by Walter Shewhart in the 1920's to stop AT&T operators from tampering with the controls to their manufacturing lines. It started as a simple pencil and paper chart, Math requirements were simple arithmetic. Control Charts were brought into widespread use by the United States during World War Two. After WWII they were introduced to Japan, and much later reintroduced back to the USA because of a TV NBC Special Report narrated by Lloyd Dobyns; "If Japan Can, Why Can't We? - 1980."¹

Dr. Wheeler wrote an article, "A Modest Proposal"² describing why he chose to rename control chart.

"It is about the continual improvement of processes and outcomes. And it is, first and foremost, a way of thinking with some tools attached."

The process behavior chart examines the data from a process to see if the process is predictable or unpredictable. The method chosen to attack continual improvement depends on whether the process is predictable or unpredictable. The process behavior charts show the way.

In this book we only consider two types of process behavior charts, the Individual and Moving Range Statistical Process Control Chart. These charts are especially useful for data consisting of one data point per time period, such as monthly sales, daily attendance, hourly traffic on a web site, quarterly **KPI's** (important business indices i.e. **Key Performance Indices**.)

¹ https://www.youtube.com/watch?v=vcG_Pmt_Ny4

² <https://vdocuments.site/a-modest-proposal-wheeler.html>



A process behavior chart is a time series plot where an upper and lower line mark the range of the usual amount of predictable variation in the data. The chart above plots quarterly sales data. The lower limit is \$2,000,000 dollars and the upper limit is \$3,100,000 dollars. The chart demonstrates the process is predictable.

One can predict that the sales will average \$2,545,400 per quarter and likely will range between \$2,000,000 and \$3,100,000 per quarter.

When a process is unpredictable, there will be patterns in the data that are detected automatically by the PBCharts software, one then cannot predict the unpredictable.

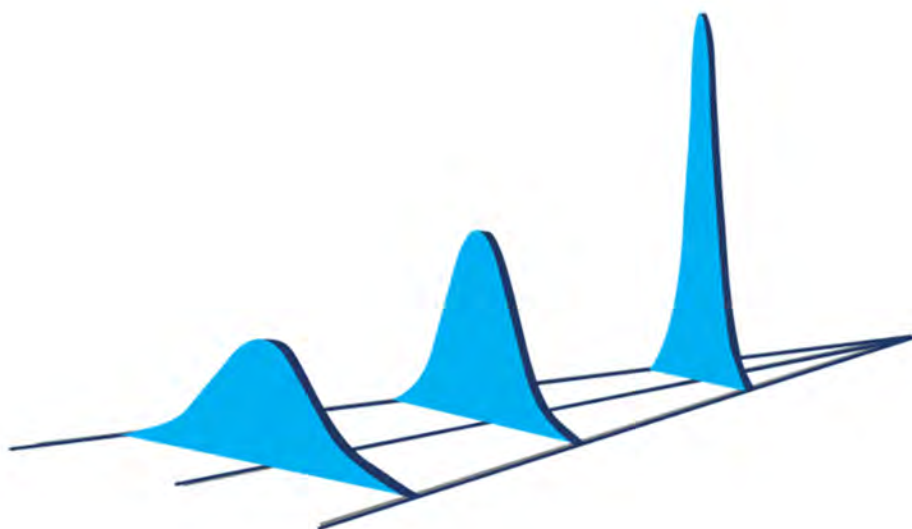
How do you plan to approach continual improvement and specifically are you intending to use it as a diagnostic tool to pick the correct process improvement method? Or are you interested in using it as a KPI monitoring and management tool? PBCharts is well suited for each application.

For diagnostic purposes PBCharts offers features to model the data from the process, stages, trends, exclusions of data points, and detection of Assignable Cause Patterns. Stages depict shifts in the data. Trends show increasing or decreasing values. Excluding data points allows removing outliers to help demonstrate predictability. Detection of assignable cause patterns identifies the data as unpredictable or the lack of assignable cause patterns identifies the data as predictable.

The choice of corrective action taken is of two basic kinds. If a process is unpredictable improvement efforts are directed to find the reasons for the assignable cause patterns so that they can be removed. If a process is predictable, improvement efforts can be directed to reducing

variability or improving the average performance. Just because a process is predictable does not mean it is meeting requirements.

When used for monitoring and management a range of data from a predictability period can be selected. The upper and lower limits are locked so that the ongoing performance can be compared to the predictable period. The predictable period can display a trend, and that trend line will be forecast forward to demonstrate if ongoing performance is still trending.



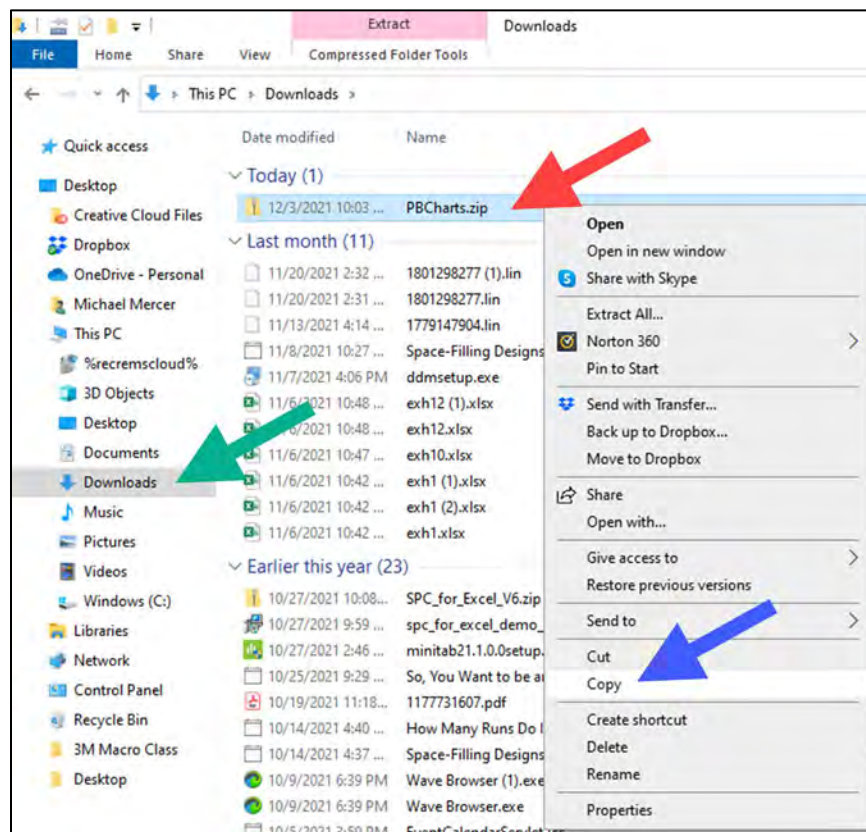
Chapter 1

DOWNLOAD AND INSTALL PBCHARTS FILES

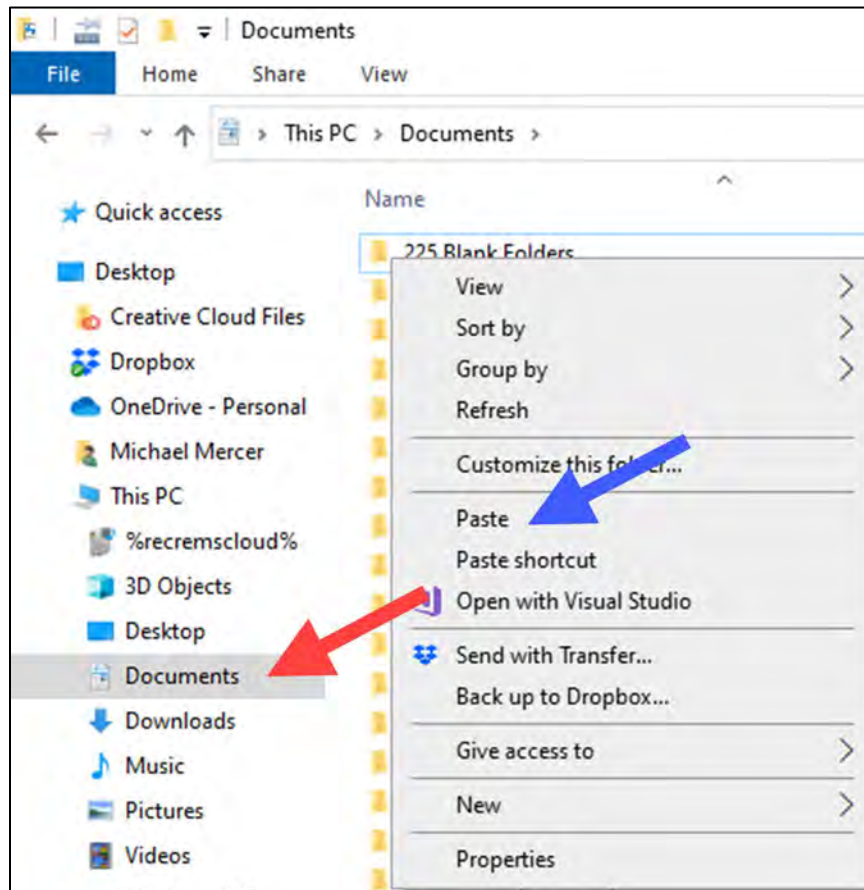
All the files needed to run the PBCharts add-in are contained in a zipped file named PBCharts.zip. The following instructions assumes you downloaded the zip file from the www.pbcharts.com website to the Downloads file folder

Follow the steps below.

- A. “Copy” the “PBCharts.zip” file from the “Downloads” folder.



B. “Paste” the PBCharts.zip file to the “Documents” Folder

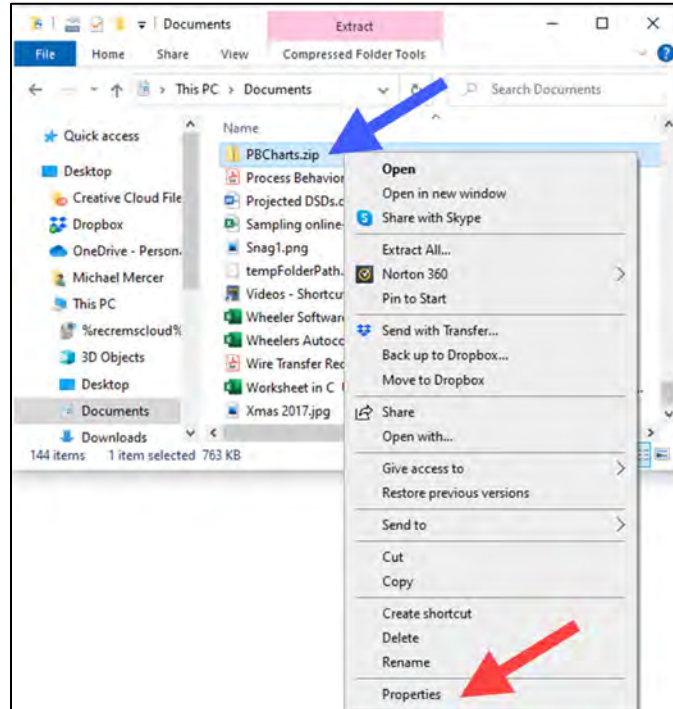


C. If the browser renames the file to something like **PBCharts-bfzaqa.zip**, change the file name to **PBCharts.zip**.

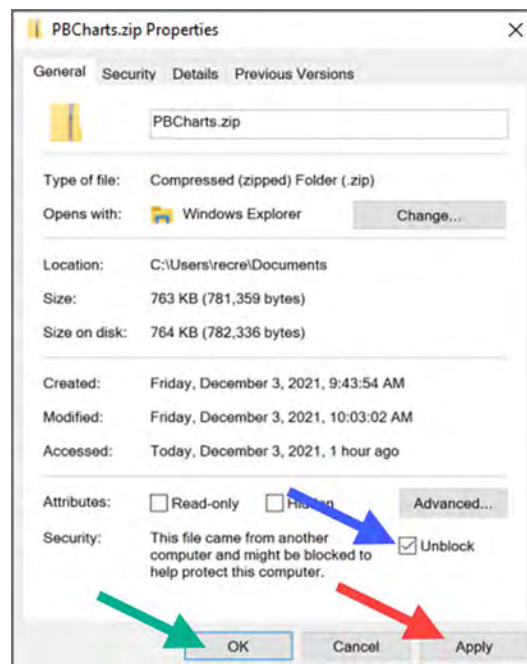
D. Unblock the zip file.

Note the file PBCharts.Zip is a blocked file and must be unblocked for the PBCharts add-in to work.

E. Right click on the “[PBCharts.zip](#)” file and select “[Properties](#)”

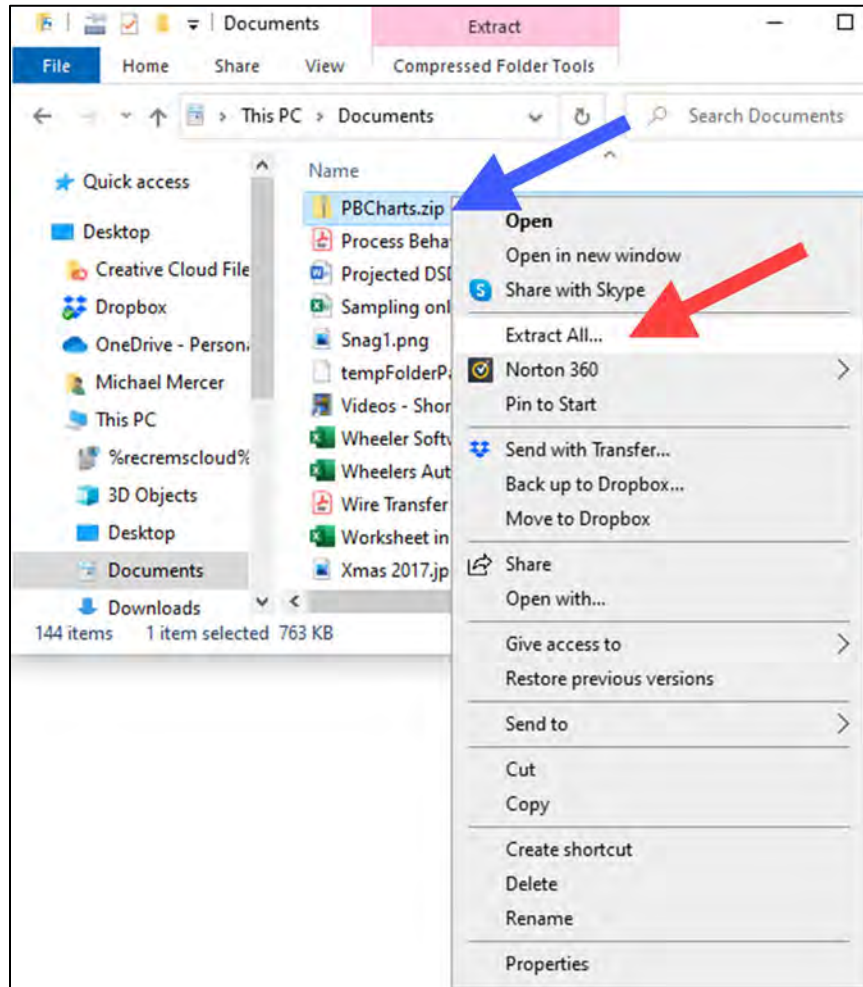


F. Check “[Unblock](#)” checkbox Click “[Apply](#)” button, then the “[OK](#)” button

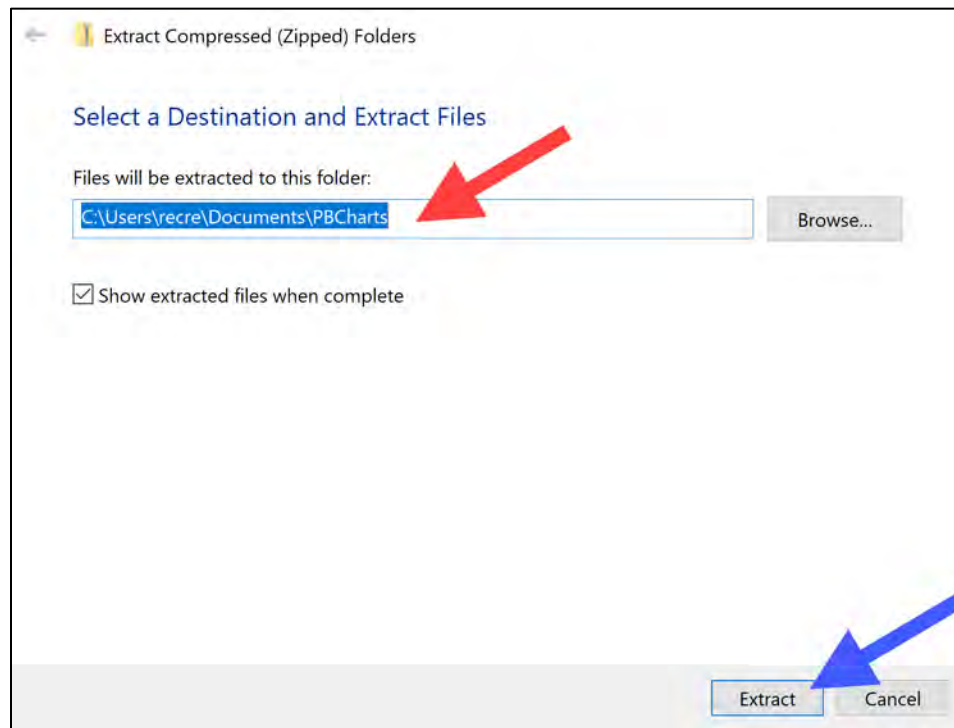


G. Extract the PBCharts Add-In from the Documents Folder

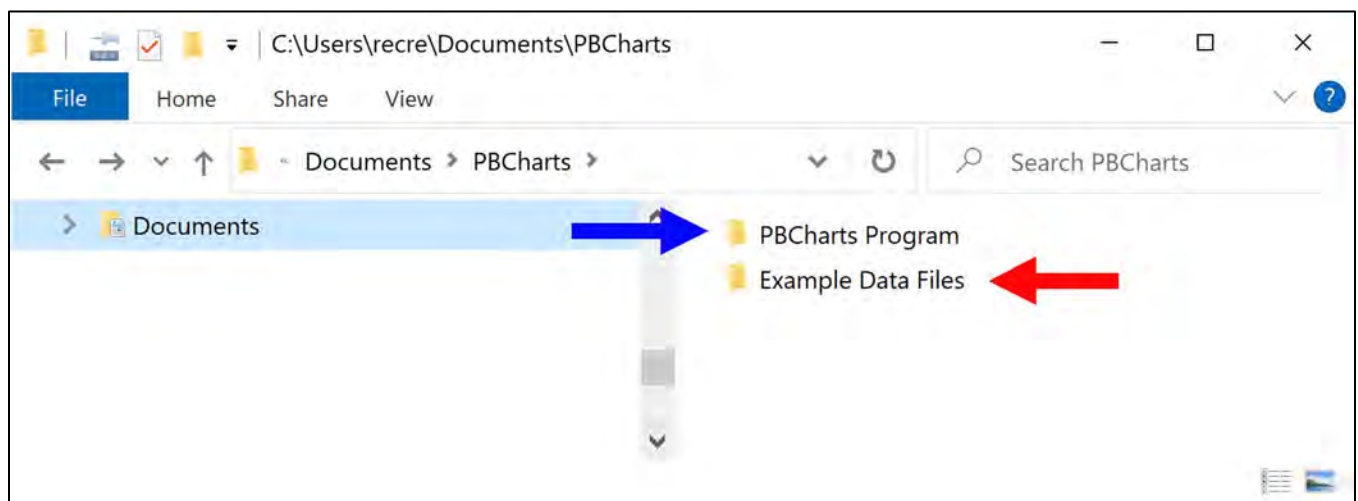
H. Right-click on the “[PBCharts.zip](#)” file, select “**Extract All**” from the pop-up menu.



- I. Press “[Extract](#)” to the suggested path, which is “[... \Documents \PBCharts](#)”.



- J. The PBCharts folder contains two folders “[PBCharts Program](#)” and “[Example Data Files](#)”.

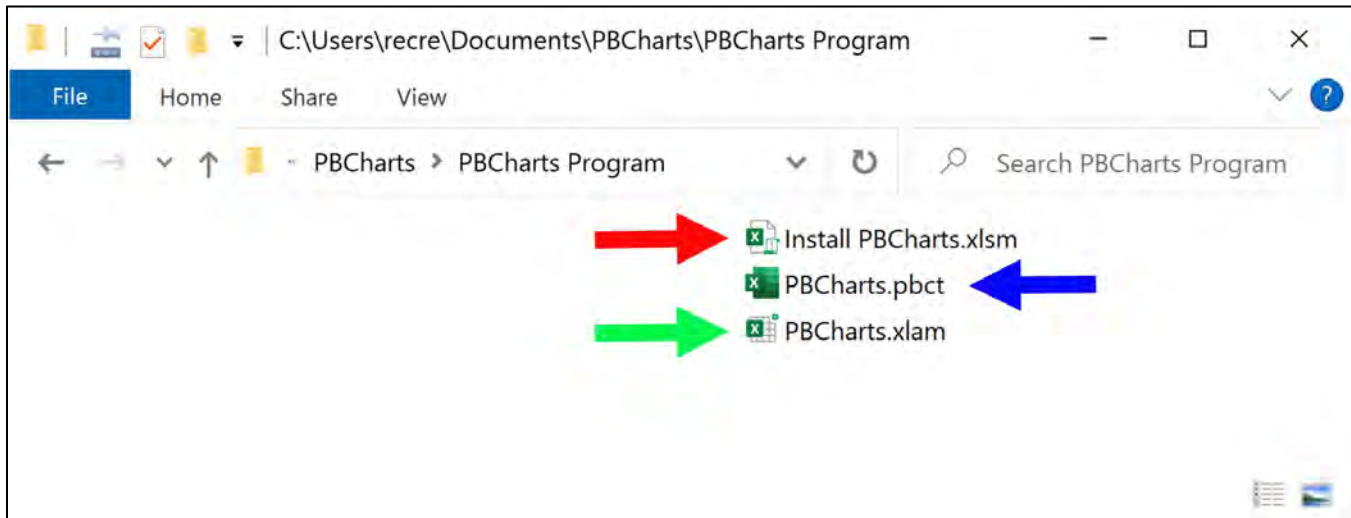


K. Inside the PBCharts Program Folder are the files:

“Install PBCharts.xlsm” is an Add-In install file

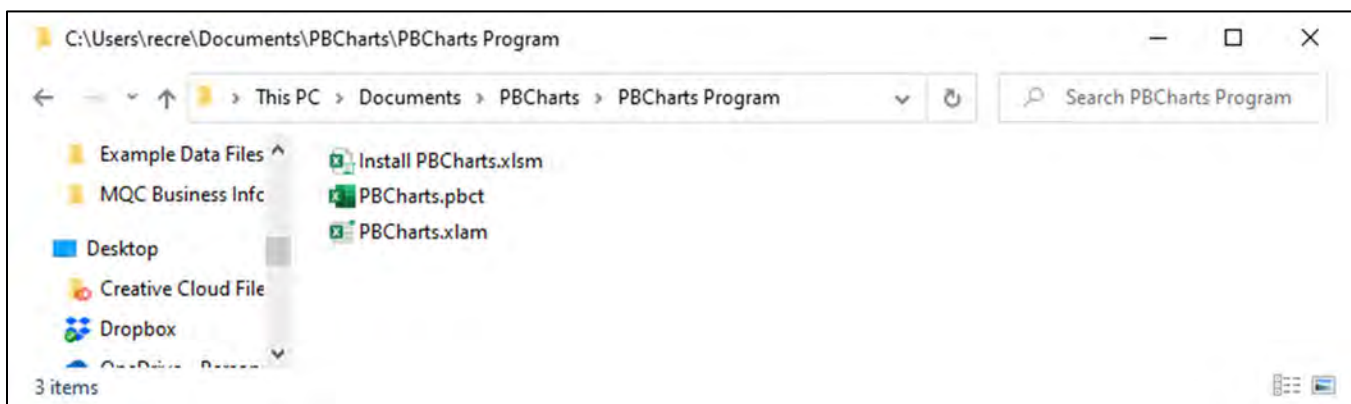
“PBCharts.pbct” is a template file, and

“PBCharts.xlam” is the add-in program file,

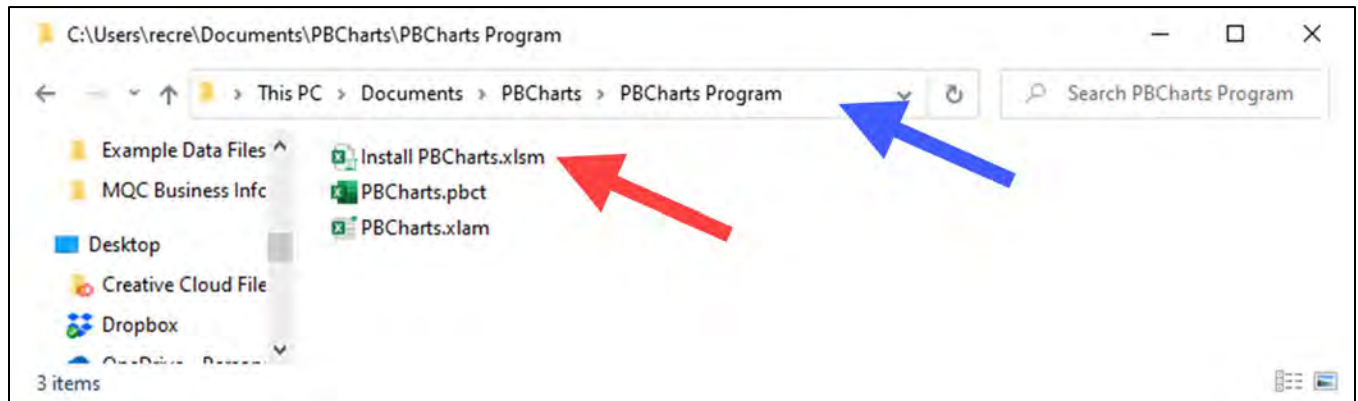


L. Install the PBCharts Add-In

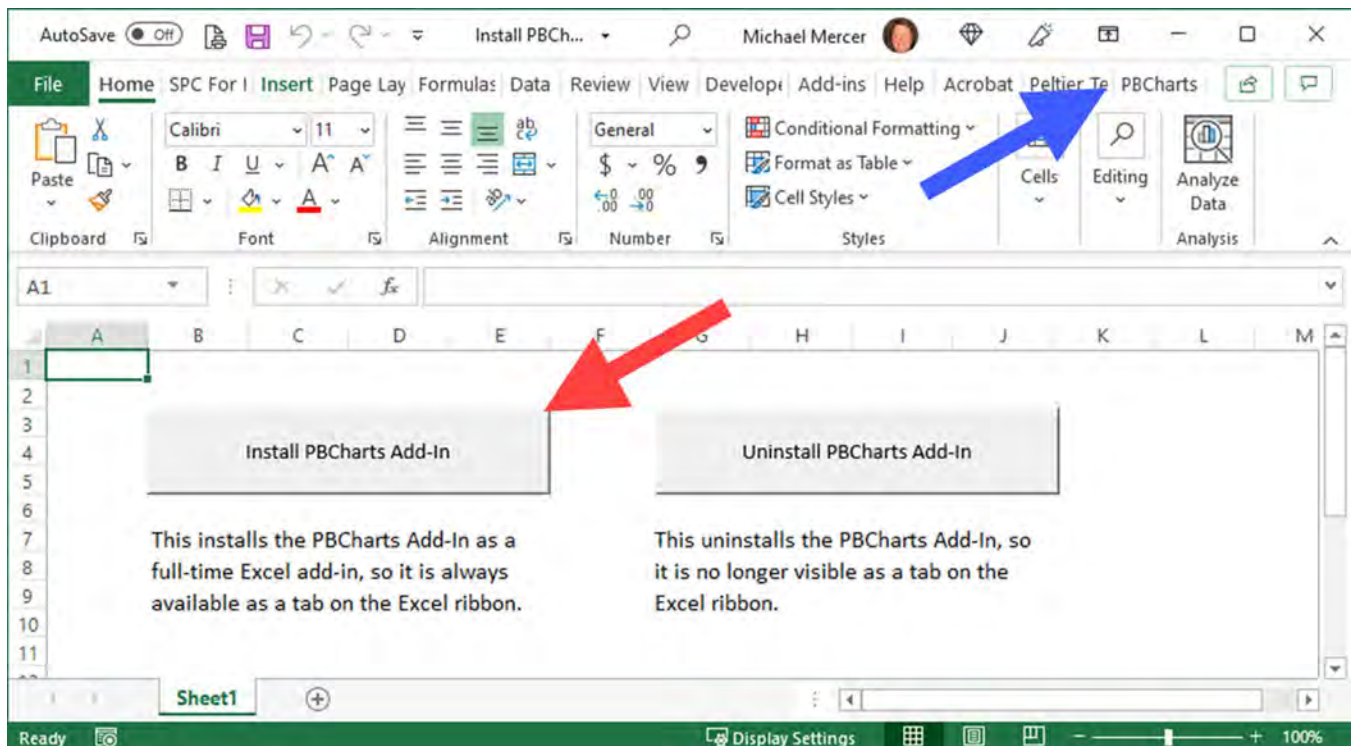
M. Browse to the “**Documents\PBCharts\PBCharts Program**” folder.



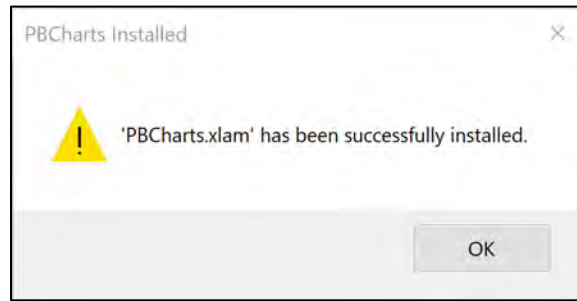
N. In the “[Documents/PBCharts/PBCharts Program](#)” folder Click on the “**Install PBCharts Add-In**” file



O. The “[PBCharts](#)” tab will appear in the ribbon at the top of the Excel window, press the “**Install PBCharts Add-In**” button.



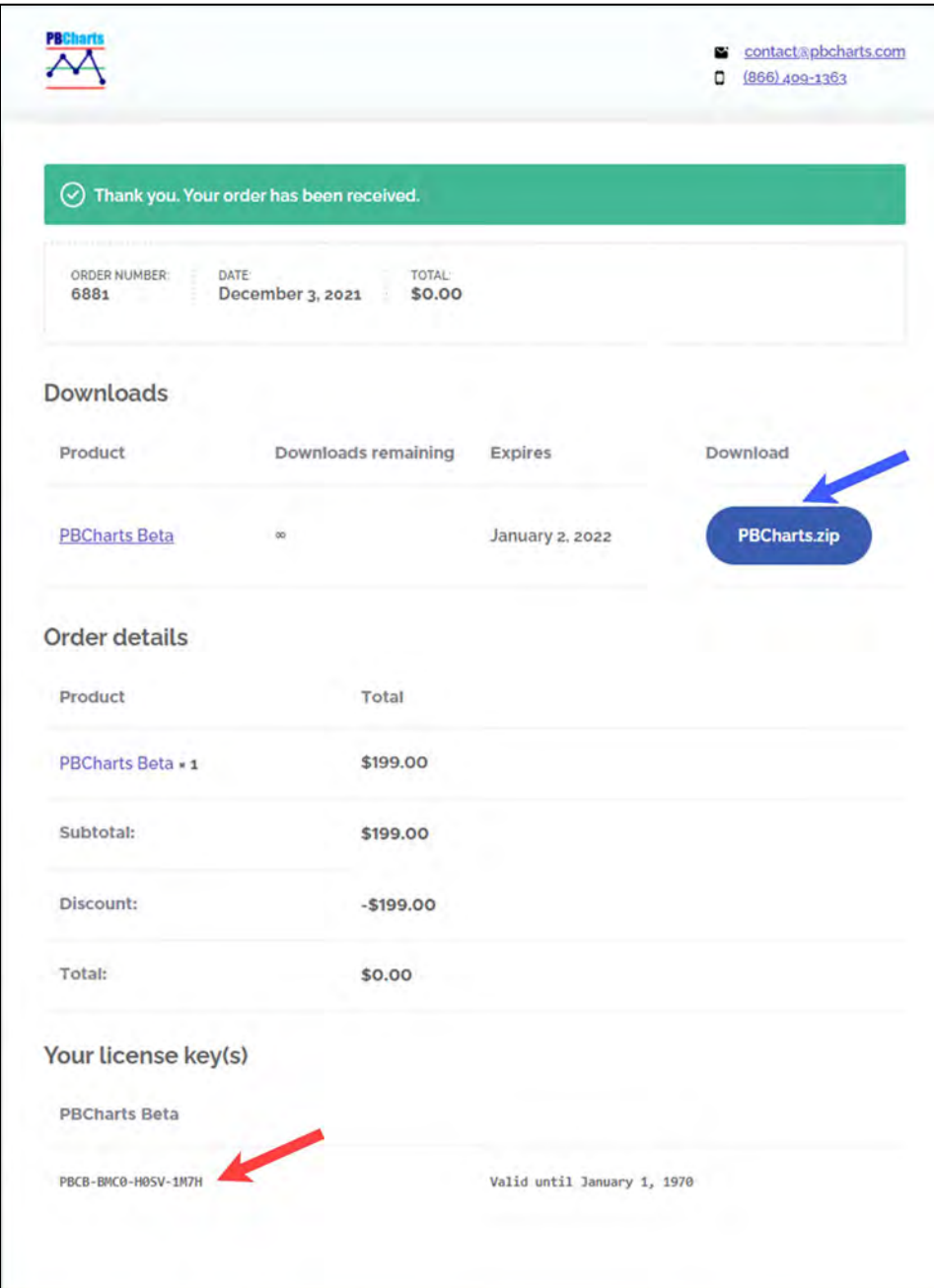
P. Installed!



Q. Close the workbook.

REGISTERING PBCHARTS SOFTWARE

Download the PBCharts.zip file by pressing the “[blue](#)” button. Capture the “[license key](#)” from the PBCharts Webpage



The screenshot displays the PBCharts website interface. At the top, the PBCharts logo is on the left, and contact information (email: contact@pbcharts.com, phone: [\(866\) 499-1363](tel:(866)499-1363)) is on the right. A green confirmation banner reads: "Thank you. Your order has been received." Below this, order details are shown: ORDER NUMBER: 6881, DATE: December 3, 2021, TOTAL: \$0.00.

The "Downloads" section contains a table with the following data:

Product	Downloads remaining	Expires	Download
PBCharts Beta	∞	January 2, 2022	PBCharts.zip

A blue arrow points to the "PBCharts.zip" download button.

The "Order details" section shows a summary of the purchase:

Product	Total
PBCharts Beta × 1	\$199.00
Subtotal:	\$199.00
Discount:	-\$199.00
Total:	\$0.00

The "Your license key(s)" section displays the license information:

Product	License Key	Valid Until
PBCharts Beta	PBCB-BMC0-H05V-1M7H	January 1, 1970

A red arrow points to the license key "PBCB-BMC0-H05V-1M7H".


Or from the confirming email download the "[PBCharts.zip](#)" and copy the "[License Key](#)".

Thanks for shopping with us

Hi Mike,

Download and install the PBCharts software, carefully following the instructions at <https://pbcharts.com/installing-pbcharts-software/> for Installing PBCharts Software.


Downloads

Product	Expires	Download
PBCharts Beta	January 2, 2022	PBCharts.zip 

[Order #6881] (December 3, 2021)

Product	Quantity	Price
PBCharts Beta	1	\$199.00
Subtotal:		\$199.00
Discount:		-\$199.00
Total:		\$0.00

Your license key(s)

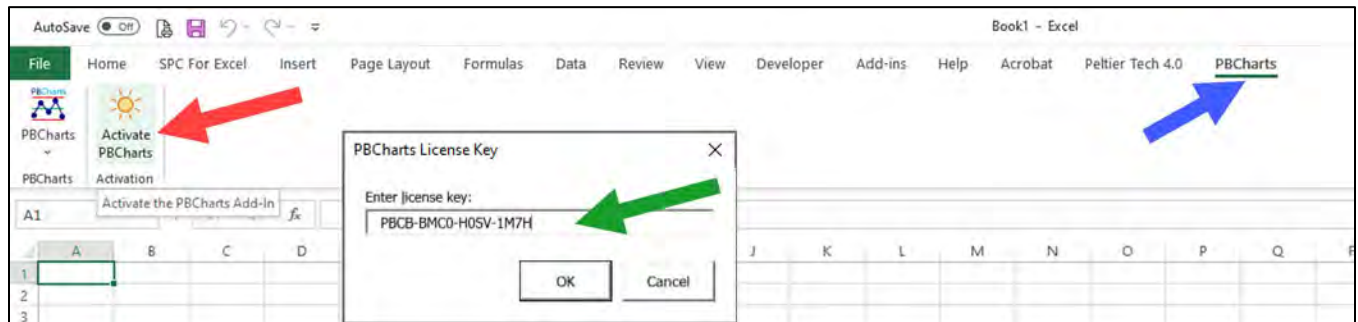
PBCharts Beta	
PBCB-BMC0-H05V-1M7H 	Valid until January 1, 1970

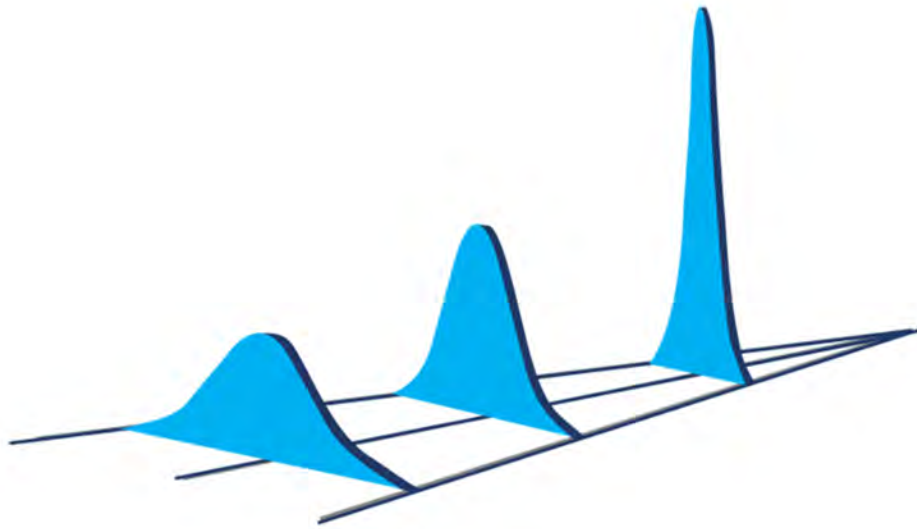
Billing address

Mike Mercer
 Mercer Quality Consulting
 1282 Saddlebrook Ln
 St. Paul, MN 55125
 16513030229
mike-merc@comcast.net

Download and install the PBCharts software, carefully following the instructions at <https://pbcharts.com/installing-pbcharts-software/>

Open Excel, press the “[BPCharts](#)” Tab. Click on the “[Activate PBCharts](#)” button and enter the “[License Key](#)”.





Chapter 2

INTRODUCTION TO PBCHARTS

This chapter gives a general overview of the features found in the PBCharts Add-in.

WHAT IS PBCHARTS

PBCharts is a program installed in Excel which enables data analysis and chart generation and the results are saved in a proprietary file structure.

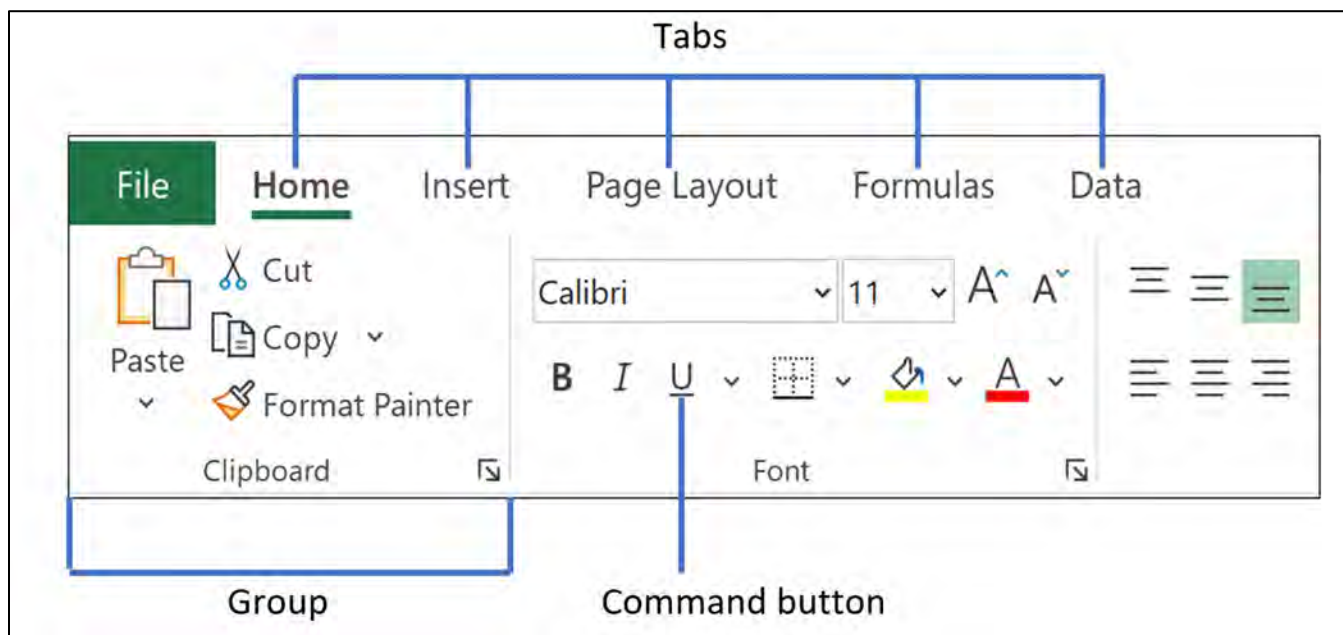
The PBCharts is installed as an Excel add-in, which means it is available every time Excel opens and its functionality is always available.

An Excel add-in is a file containing code that performs unique actions and a user interface containing a ribbon which has icons to enable the add-in's functions.

EXCEL RIBBON

An **Excel ribbon** is the row of tabs and icons at the top of the Excel window that allows you to quickly find and use commands for completing tasks.

The ribbon contains tabs, groups, and controls such as icons, buttons, checkboxes, and menus.

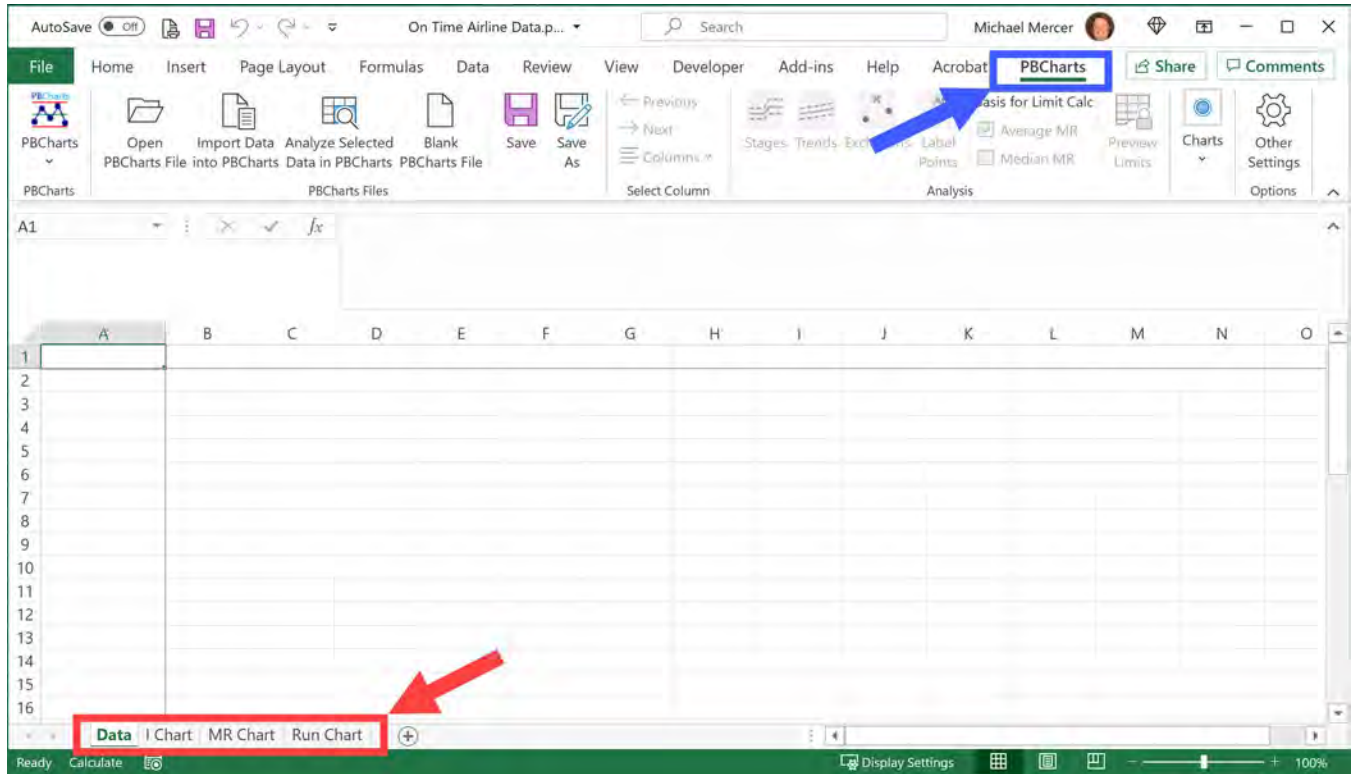


Ribbon tab contains multiple commands logically sub-divided into groups.

Ribbon group is a set of closely related commands normally performed as part of a larger task.

A **control** is an icon, button, check box, menu, or other feature that you click to perform a particular action.

PBCHARTS INTERFACE

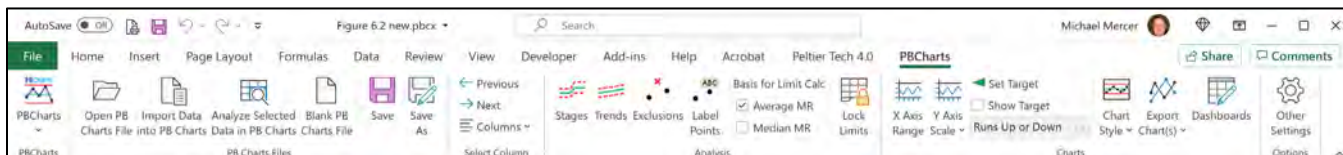


The PBCharts add-in has a ribbon tab named **"PBCharts"**. PBCharts displays four worksheets: **"Data, I Chart, MR Chart and Run Chart"**. The Data worksheet contains data that is charted in the three other worksheets. Charts can be configured with the icons on the ribbon.

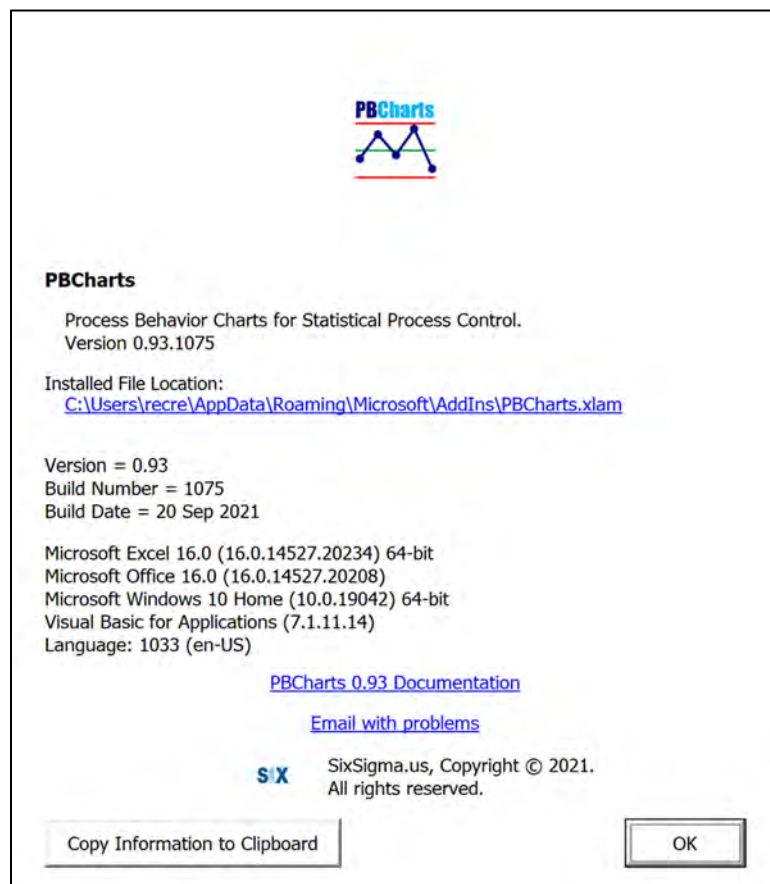
The first row of the Data tab is reserved for data names, the first column is the date or otherwise the x axis column. Subsequent columns contain the data to be charted, headed by a unique name. in row 1.

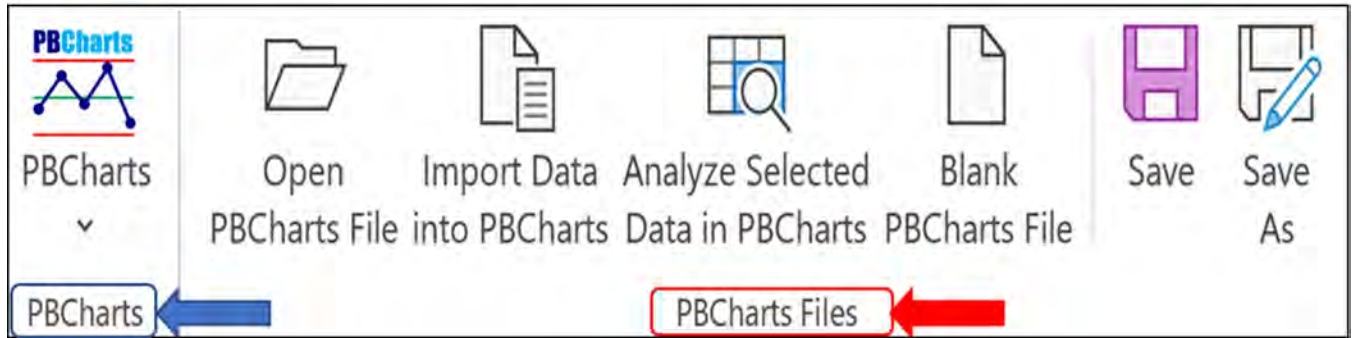
PBCHARTS GROUPS

The width of the PBCharts ribbon, Figure 2.3, is too wide to clearly see its contents, so we'll examine it group by group. The specific use of the icons on the ribbon will be extensively demonstrated in later chapters.



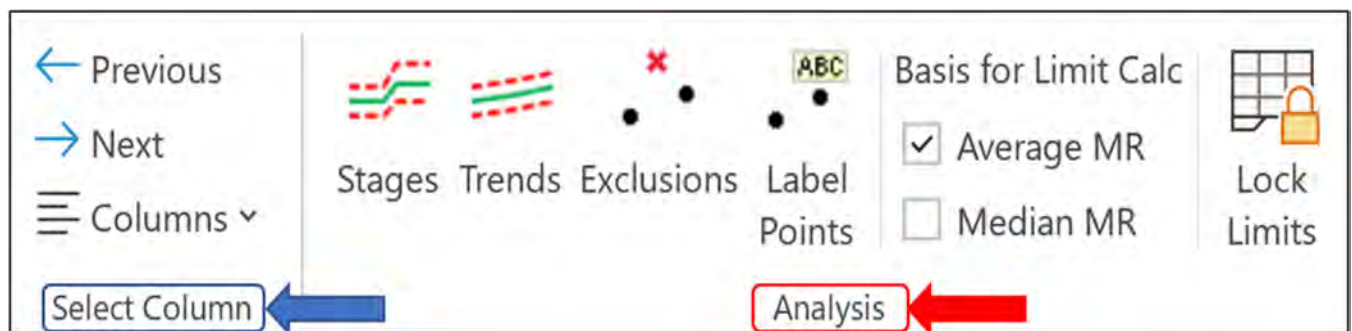
The first group has an icon, “PBCharts”, it contains information on the revision, location of the add-in file, and a link to additional information.”





The second group, **PBCharts Files** contains the icons to open, import, analyze data in a new PBCharts file. The icon **Blank PBCharts File** creates a new file you can use to paste data from another application. The **Save** icon saves the active PBCharts file. The **Save As** icon saves a PBChart file with a new name. These icons will be discussed further in later chapters.

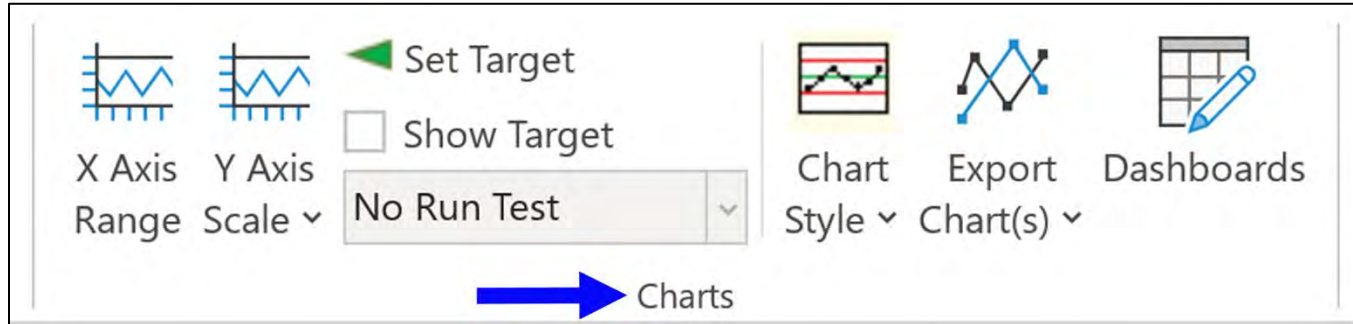
The **Select Column** and **Analysis** groups have icons that edit the chart worksheets. The icons on the **Select Column** Group has icons allowing moving the view from one data column to another.



The **Analysis** Group is used to model the data to represent its most salient graphical information. The **Stages** icon can be used to model a shift in the data. Linear or exponential trends can be modeled within stages using the **Trends** icon. The **Exclusions** icon is used to remove data points identified with assignable causes patterns. The **Label Points** icon appends explanatory information to individual data points and shows up on all three charts, I, MR and Run Charts.

The icon **Basis for Limit Calc** icon contains a check box for selecting either the Average Moving Range or the Median Moving Range. The **Lock Limits** icon freezes the values of the Natural Process Behavior Limits so that one can judge future behavior compared to the selected base period.

The “[Charts](#)” Group allows further configuration of the charts.



The “**X Axis Range**” and “**Y Axis Range**” icons can customize the axis values.

The “**Set Target**” icon and the “**Show Target**” icon can add a target individually to each individual chart or add a universal value to each chart.

The “**No Runs Test**” icon is enabled only when the Runs Chart worksheet is selected. It has two runs tests to help judge the randomness of the data.

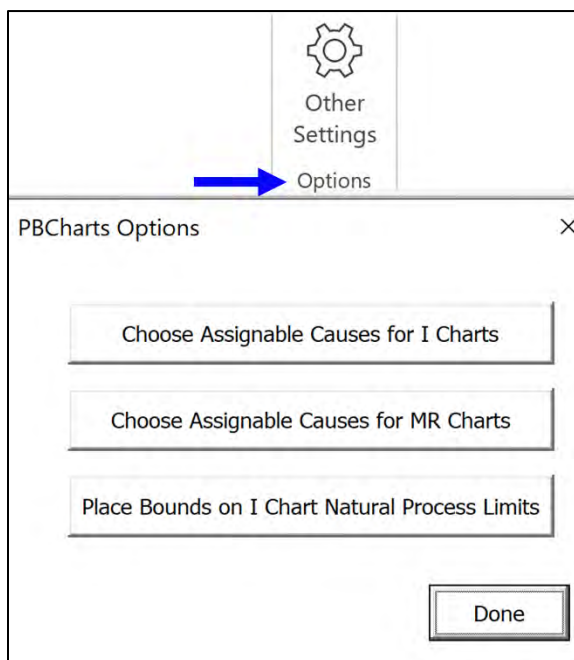
The “**Chart Style**” icon allows customization of the chart elements from light to bold.

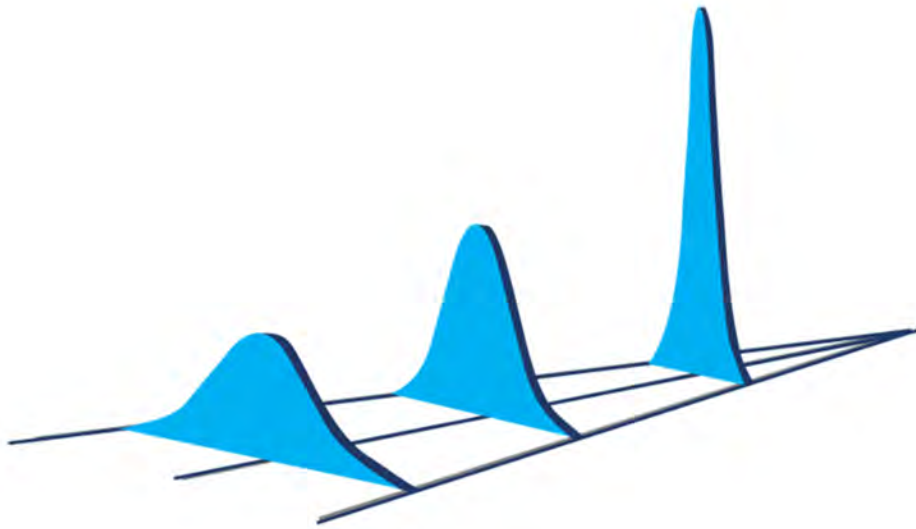
The “**Charts Style**” icon can display three zones that the assignable cause pattern tests are based on. The lines can be used as an aid in understanding how the assignable cause pattern tests are triggered.

The “**Export Chart(s)**” icon exports the current selected chart to Word, or Power Point, and you can save the chart to an Adobe pdf file or an png image file.

The “**Dashboards**” icon adds multiple charts to a single page that can be formatted for printing in different sizes.

The “**Other Settings**” icon in the “**Options**” group allows selection of the specific Assignable Cause Patterns tests for the I Chart and MR Chart, and can place bounds on the process limits to prevent display of impossible values such as negative values for KPIs that are always positive.



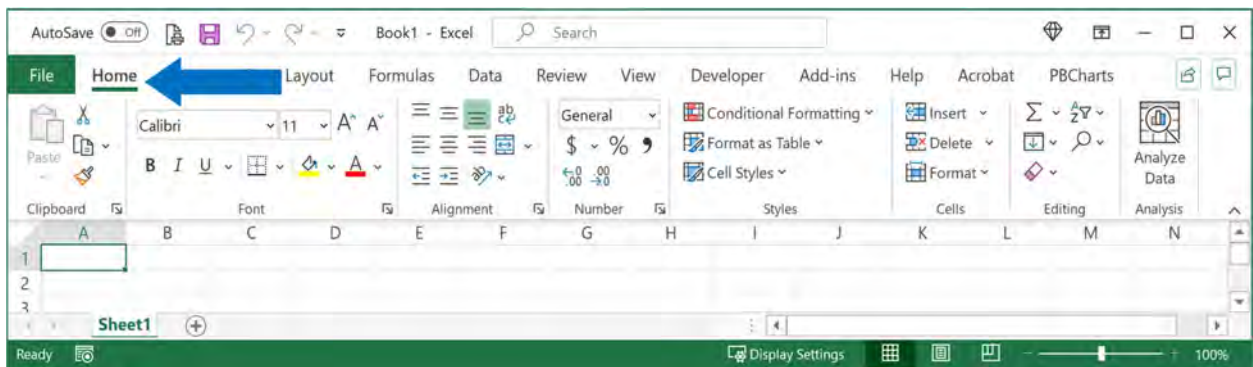


Chapter 3

PBCHARTS FILES GROUP

There are four ways to bring data into PBCharts and they are described in detail in this chapter. The data winds up in the permanent worksheet tab appropriately called “Data”.

Opening Excel after the PBCharts Add-In has been installed will bring you to the “[Home](#)” Tab.



Press the “[PBCharts](#)” Tab and the PBCharts Ribbon appears.

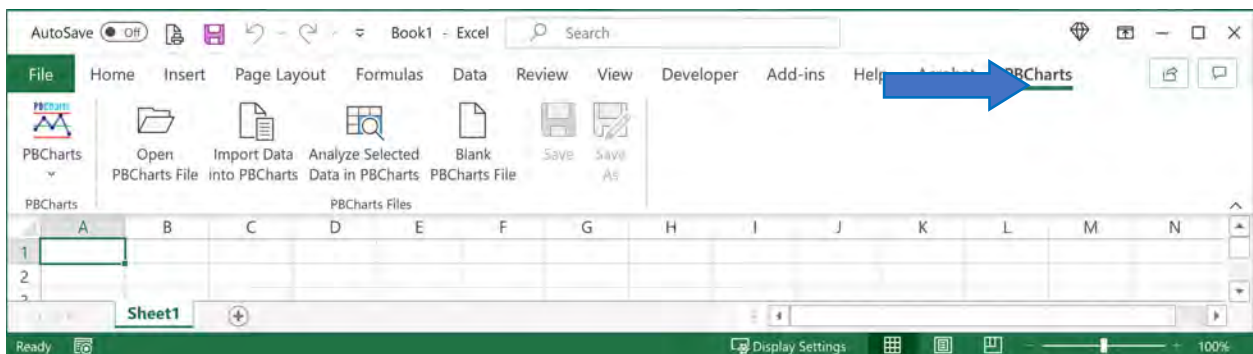
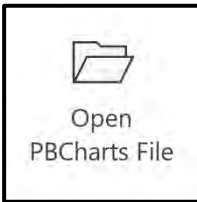


Figure 3.2 - PBCharts Tab

OPENING FILES IN PBCHARTS

There are four ways You can add data to the data worksheet.



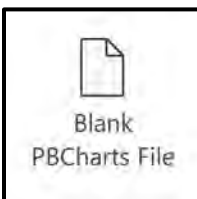
Opens an existing PBCharts file which has a pbcx filename extension.



Import data from Excel, CSV, Text and PBCharts files into a new PBCharts file.



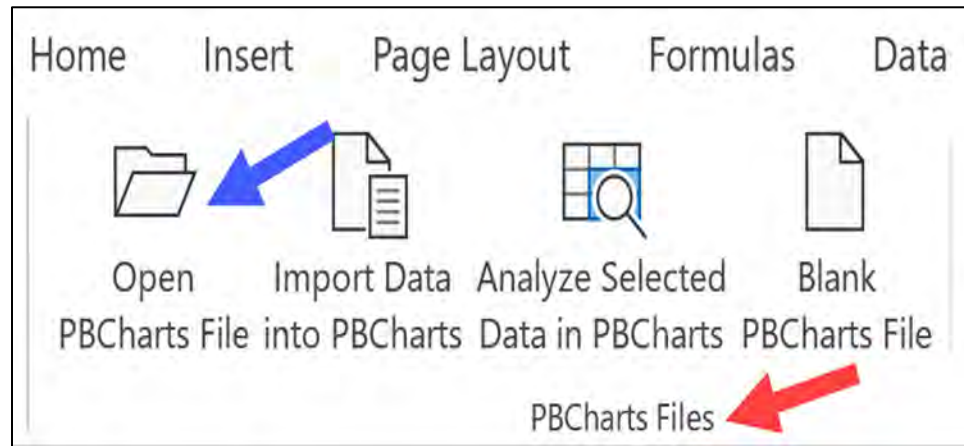
Select data from an Excel worksheet to be analyzed in a new PBCharts file.



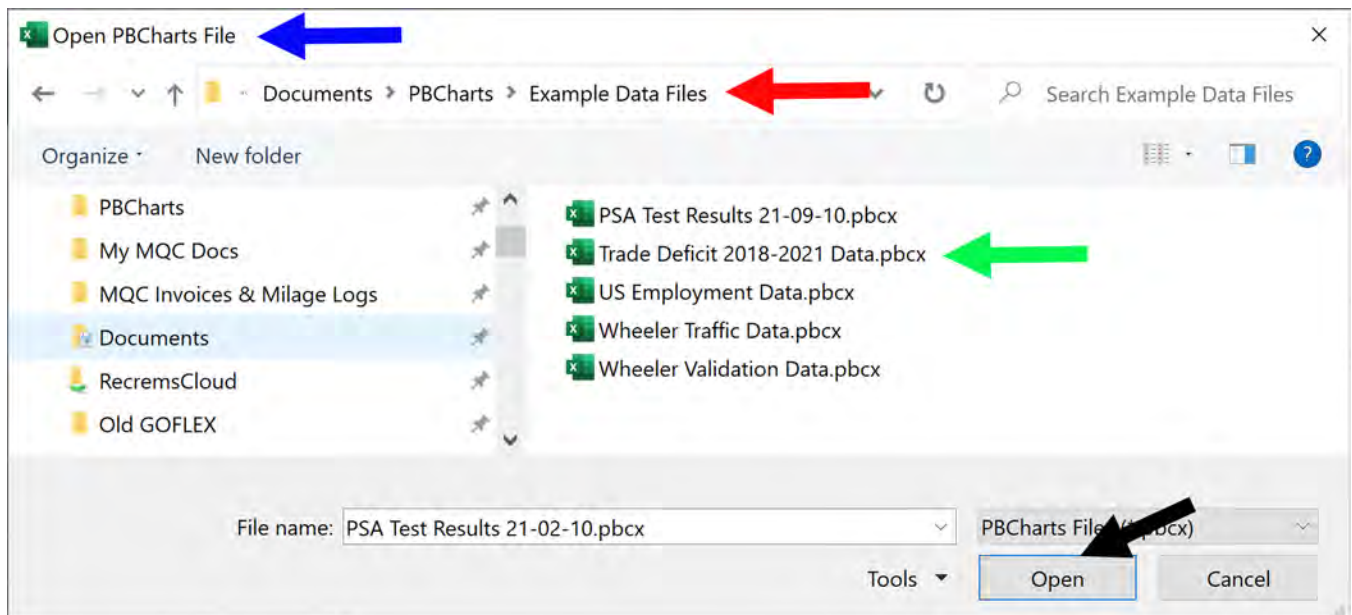
Opens a blank PBCharts and allows pasting data.

The four icons used to open files are found in the “**PBCharts**” Group.

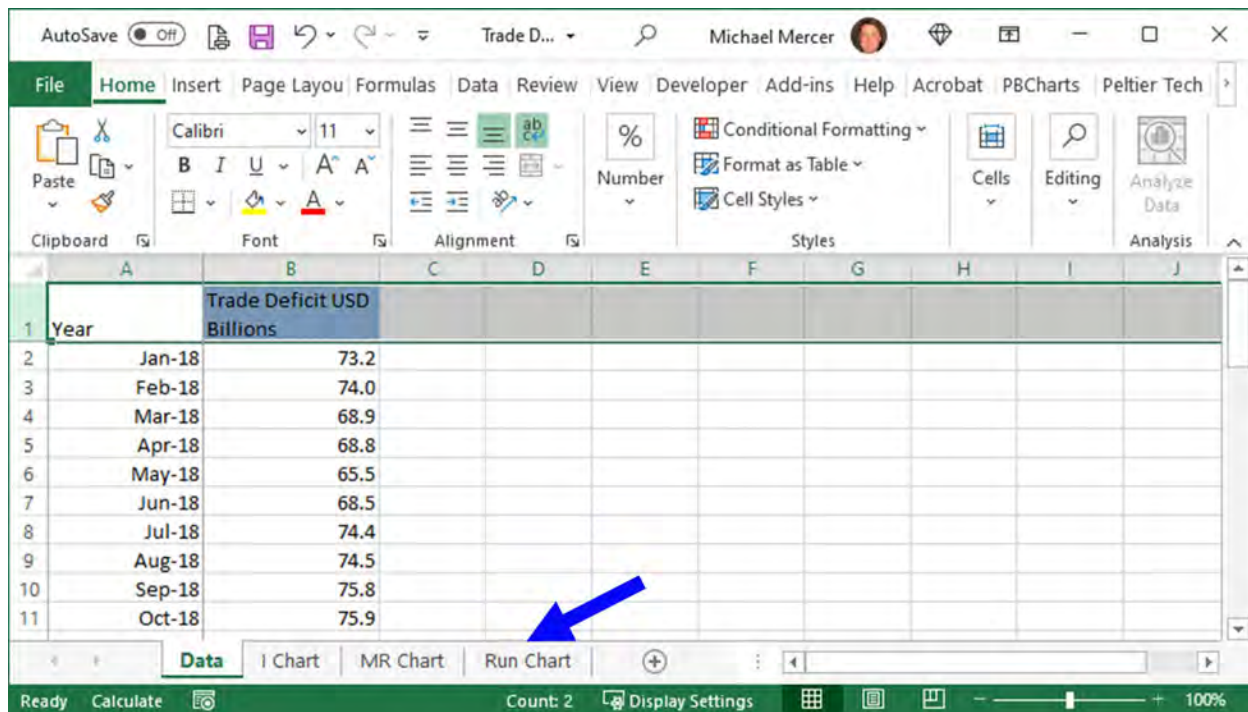
Press the “[Open PB Charts File](#)” icon in the “**PB Charts Files**” group.



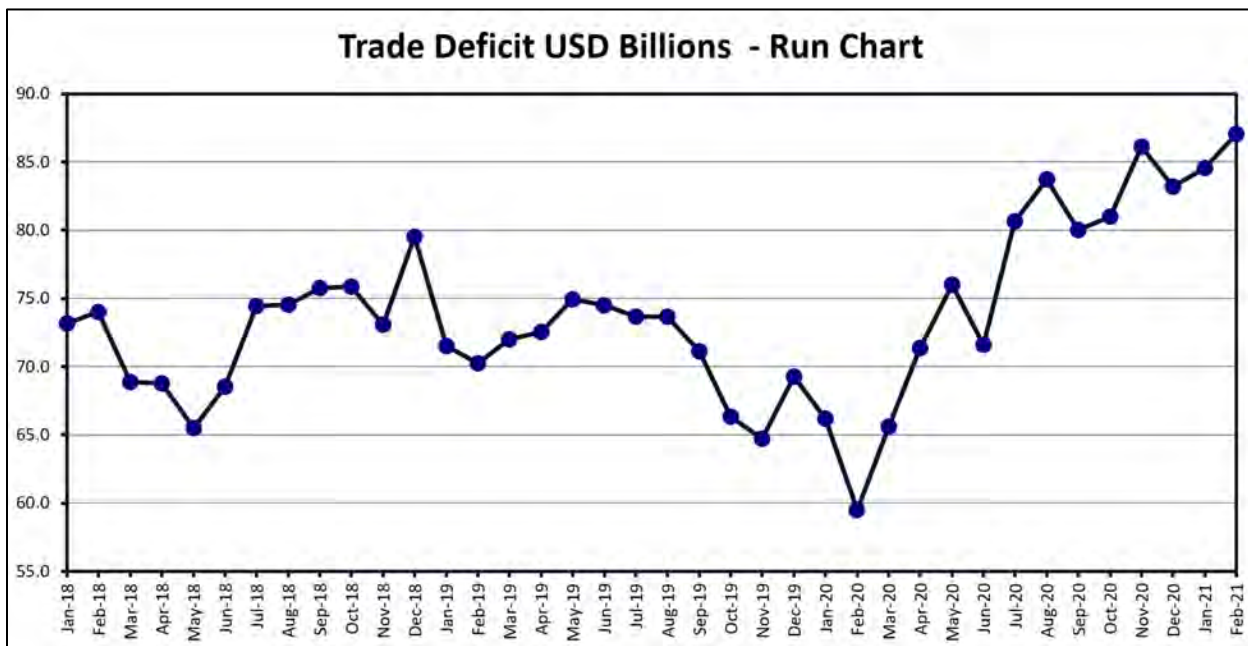
The “[Open PBCharts File](#)” dialog box opens to the Documents folder. Navigate to the “[Documents\PBCharts\Example Data Files](#)” folder and select “[Trade Deficit 2018 – 2021 Data](#)” and click the “**Open**” button.



Press the “[Run Chart](#)” Tab at the bottom of the screen.



A run chart is another name for a time series chart.



IMPORTING DATA INTO PBCHARTS



Pressing the “Import Data into PBCharts” icon opens a dialog box, see Figure 3.7, that has as a priority four data types to import:

1. Excel Files ending with *.xlsx, *.xlsm.
2. CSV data files ending with *.csv
3. Text data files ending with *.txt, *.tab
4. PBCharts data files ending in *.pbcx can also be opened, however just the raw data will be imported; all formatting and configuration of the data is ignored.
5. Using the All Files (*.*) option, other types that are compatible with Excel such as *.xls files can also be imported.

If a selected file has multiple worksheet tabs (Excel or PBCharts files), PBCharts only imports data from the first worksheet. PBCharts performs some rudimentary cleanup on the file, such as removing empty rows or columns and converting numbers-stored-as-text into numbers

After pressing the “**Import Data into PBCharts**” icon, select the “Trade Deficit 2018 -2021 Data.xlsx” file located in the folder “...Documents\PBCharts\Example Data Files” that comes with PBCharts.

Next the “[Select Data File to Import](#)” dialog opens. Select the file “[Trade Deficit for 2018-2021 Data.xlsx](#)” and press “[Open](#)”.

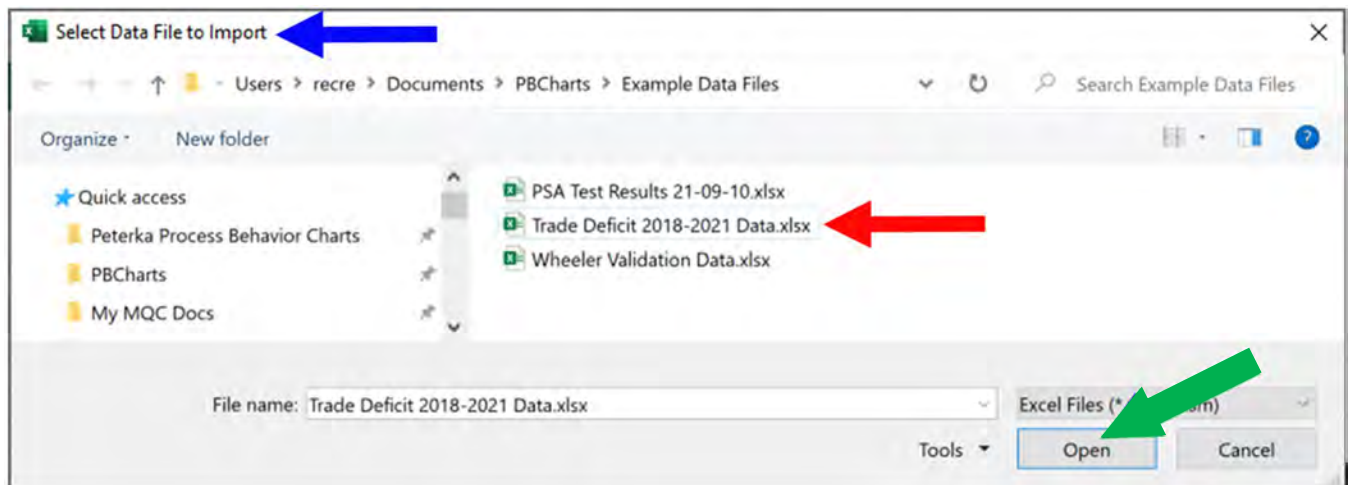


Figure 3.7 - Importing a Native Excel File

A new PBCharts data file is created in the “[Select Folder and Name for New PBCharts](#)

[File](#)” dialog by default. It uses the same file name as the xlsx file but adds the pbcx filename extender naming the file “**Trade Deficit 2018-32021.pbcx**” Press the “**Save**” button

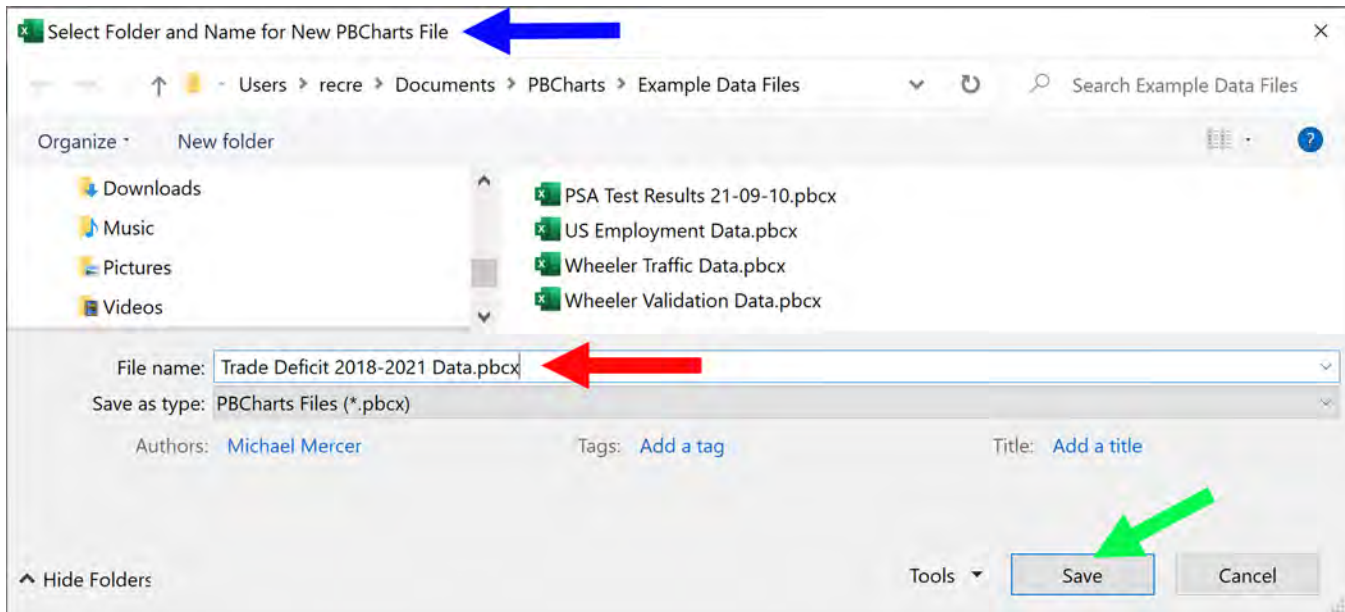


Figure 3.8 - Saving the new PBCharts Data File

The new PBCharts file is saved in the same location as the original Excel file.

ANALYZING SELECTED DATA IN PBCHARTS



This somewhat awkward phrase serves to remind you that if there is data in an existing worksheet, you can just select it then go to the PBCharts Tab and press the Analyze Selected Data in PBCharts.

There are a few characteristics that make data suitable for a PBCharts analysis:

- The data should be contiguous, with no blank rows or columns. Blank cells are acceptable and often unavoidable.
- The data should be arranged by columns, with each column representing a variable, and each row representing an observation or record of each variable.
- The top row (one row only) should contain headers or labels with the name of each column's variable. It is advised that these be kept as short as possible.
- The leftmost column (one column only) should be an identifier of each row's observations. This could be a date, a batch number, or similar identifier.

Go to the Home tab and Open the file "Business Data.xls" as you normally open an Excel file. It is in the "...Documents\PBCharts\Example Data Files\ folder.

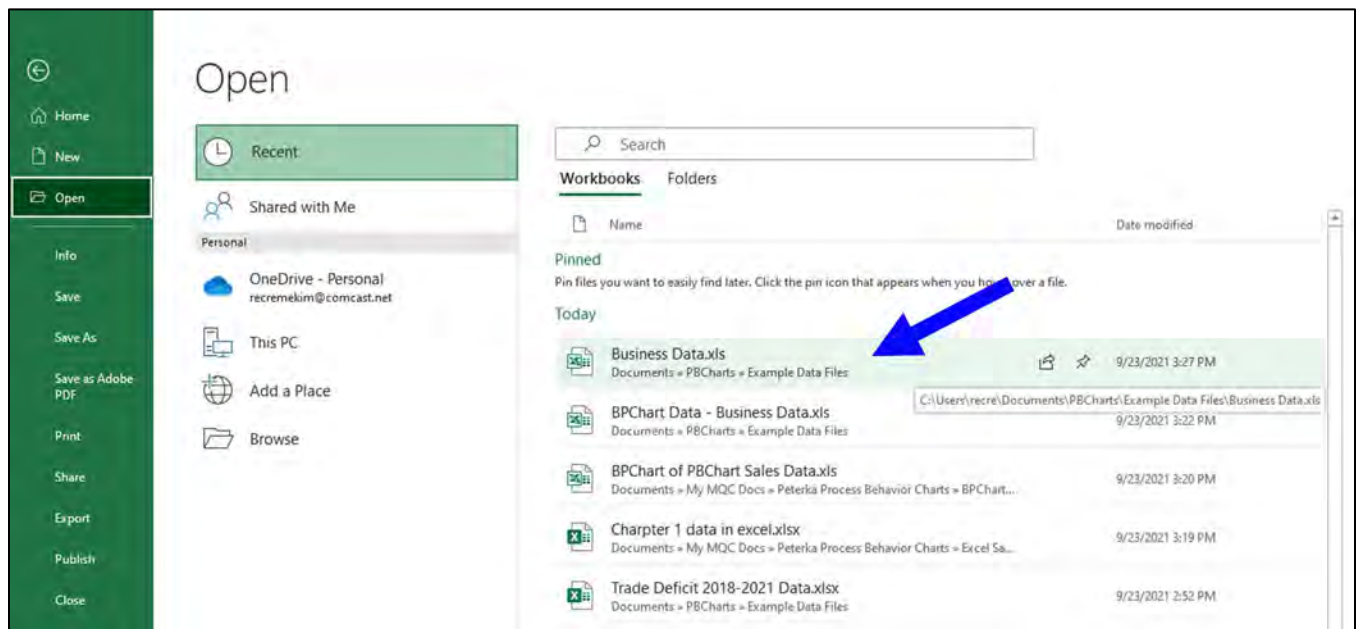


Figure 3.9 - Opening Existing Data in an Excel Worksheet

We only want the data in Columns B to L and rows 13 to 36.

The screenshot displays the PBCharts application window. The ribbon menu at the top includes File, Home, Insert, Page Layout, Formulas, Data, Review, View, Developer, Add-ins, Help, Acrobat, PBCharts, and Peltier Tech 4.1. The main workspace shows a spreadsheet with columns A through M and rows 1 through 37. The data is organized into a table starting at row 13, column B. The table includes headers for various financial and operational metrics, such as Income, Expenses, % Waste, Sales Credits, Profit Prod, Centerline, Index A, and Index B. The data spans from January 2010 to November 2011.

	Month	Income	Expenses	% Waste Dept 1	% Waste Dept 2	% Waste Dept 3	Sales Credits	Profit Prod A	Centerline	Index A	Index B
13	Jan-10	2359	1595	0.3	4.5	8.7	17.86	4.45	4.7	0.31	4.45
14	Feb-10	2333	1962	2.3	3.2	7.8	15.87	3.22	4.9	2.35	3.22
15	Mar-10	2098	1888	2.6	6.4	7.9	15.89	6.38	5.1	2.60	6.38
16	Apr-10	2049	2059	2.3	5.2	9.0	17.44	5.18	5.2	2.27	5.18
17	May-10	2271	1686	0.2	5.7	7.6	16.69	5.69	5.4	0.22	5.69
18	Jun-10	2069	1782	2.1	5.4	8.3	12.21	5.39	5.6	2.08	5.39
19	Jul-10	2149	1532	0.5	6.0	7.2	17.13	6.01	5.8	0.46	6.01
20	Aug-10	2124	2196	2.2	5.9	7.5	15.47	5.88	5.9	2.21	5.88
21	Sep-10	2014	2036	2.8	6.5	7.7	13.37	6.54	6.1	2.75	6.54
22	Oct-10	2246	1733	0.0	6.2	7.8	17.20	6.17	6.3	0.02	6.17
23	Nov-10	2208	2144	0.3	6.3	8.8	17.41	6.28	6.5	0.29	6.28
24	Dec-10	2341	1714	0.6	6.1	8.7	13.43	6.12	6.6	0.65	6.12
25	Jan-11	2214	2018	1.6	7.3	7.8	17.51	12.27	11.8	3.65	7.27
26	Feb-11	2418	1818	2.4	6.7	7.7	16.93	11.74	12.0	4.38	6.74
27	Mar-11	2220	1841	0.4	7.9	8.5	17.31	12.88	12.2	2.40	7.88
28	Apr-11	2037	1565	0.6	8.7	9.8	16.80	13.67	12.3	2.64	8.67
29	May-11	2181	1744	2.9	6.5	9.9	14.22	11.51	12.5	4.90	6.51
30	Jun-11	2033	2035	2.3	8.7	7.1	15.32	13.75	12.7	4.28	8.75
31	Jul-11	2434	1518	1.5	7.8	8.8	17.95	12.77	12.9	3.48	7.77
32	Aug-11	2134	1684	1.7	7.1	7.9	19.35	12.13	13.0	3.73	7.13
33	Sep-11	2349	2164	0.6	9.0	9.7	12.73	13.96	13.2	2.55	8.96
34	Oct-11	2305	2121	1.2	7.7	7.5	19.04	12.73	13.4	3.16	7.73
35	Nov-11	2147	1774	1.0	8.0	8.4	17.36	12.98	13.6	3.01	7.98

Figure 3.10 - Selecting Data further analysis in PBCharts

Select the range “**B13 to L36**” and press the “**PBCharts**” Tab and then press the “**Analyze Selected Data in PBCharts**” button.

The screenshot shows the PBCharts software interface with the 'PBCharts' tab selected in the ribbon. The ribbon contains buttons for 'Open', 'Import Data', 'Analyze Selected Data in PBCharts', 'Blank', 'Save', and 'Save As'. A red arrow points to the 'PBCharts' tab, and a blue arrow points to the 'Analyze Selected Data in PBCharts' button. A green box highlights the data range B13:L36 in the spreadsheet.

Month	Income	Expenses	% Waste Dept 1	% Waste Dept 2	% Waste Dept 3	Sales Credits	Profit Prod A	Centerline	Index A	Index B
Jan-10	2359	1595	0.3	4.5	8.7	17.86	4.45	4.7	0.31	4.45
Feb-10	2333	1962	2.3	3.2	7.8	15.87	3.22	4.9	2.35	3.22
Mar-10	2098	1888	2.6	6.4	7.9	15.89	6.38	5.1	2.60	6.38
Apr-10	2049	2059	2.3	5.2	9.0	17.44	5.18	5.2	2.27	5.18
May-10	2271	1686	0.2	5.7	7.6	16.69	5.69	5.4	0.22	5.69
Jun-10	2069	1782	2.1	5.4	8.3	12.21	5.39	5.6	2.08	5.39
Jul-10	2149	1532	0.5	6.0	7.2	17.13	6.01	5.8	0.46	6.01
Aug-10	2124	2196	2.2	5.9	7.5	15.47	5.88	5.9	2.21	5.88
Sep-10	2014	2036	2.8	6.5	7.7	13.37	6.54	6.1	2.75	6.54
Oct-10	2246	1733	0.0	6.2	7.8	17.20	6.17	6.3	0.02	6.17
Nov-10	2208	2144	0.3	6.3	8.8	17.41	6.28	6.5	0.29	6.28
Dec-10	2341	1714	0.6	6.1	8.7	13.43	6.12	6.6	0.65	6.12
Jan-11	2214	2018	1.6	7.3	7.8	17.51	12.27	11.8	3.65	7.27
Feb-11	2418	1818	2.4	6.7	7.7	16.93	11.74	12.0	4.38	6.74
Mar-11	2220	1841	0.4	7.9	8.5	17.31	12.88	12.2	2.40	7.88
Apr-11	2037	1565	0.6	8.7	9.8	16.80	13.67	12.3	2.64	8.67
May-11	2181	1744	2.9	6.5	9.9	14.22	11.51	12.5	4.90	6.51
Jun-11	2033	2035	2.3	8.7	7.1	15.32	13.75	12.7	4.28	8.75
Jul-11	2434	1518	1.5	7.8	8.8	17.95	12.77	12.9	3.48	7.77
Aug-11	2134	1684	1.7	7.1	7.9	19.35	12.13	13.0	3.73	7.13
Sep-11	2349	2164	0.6	9.0	9.7	12.73	13.96	13.2	2.55	8.96
Oct-11	2305	2121	1.2	7.7	7.5	19.04	12.73	13.4	3.16	7.73
Nov-11	2147	1774	1.0	8.0	8.4	17.36	12.98	13.6	3.01	7.98

Figure 3.11 - Importing Selected Data into PBCharts

Once imported into PBCharts Add-in, the file is automatically saved with the same name as the original file, in the same folder but with the added pbcx filename extender, "[Business Data.pbcx](#)"

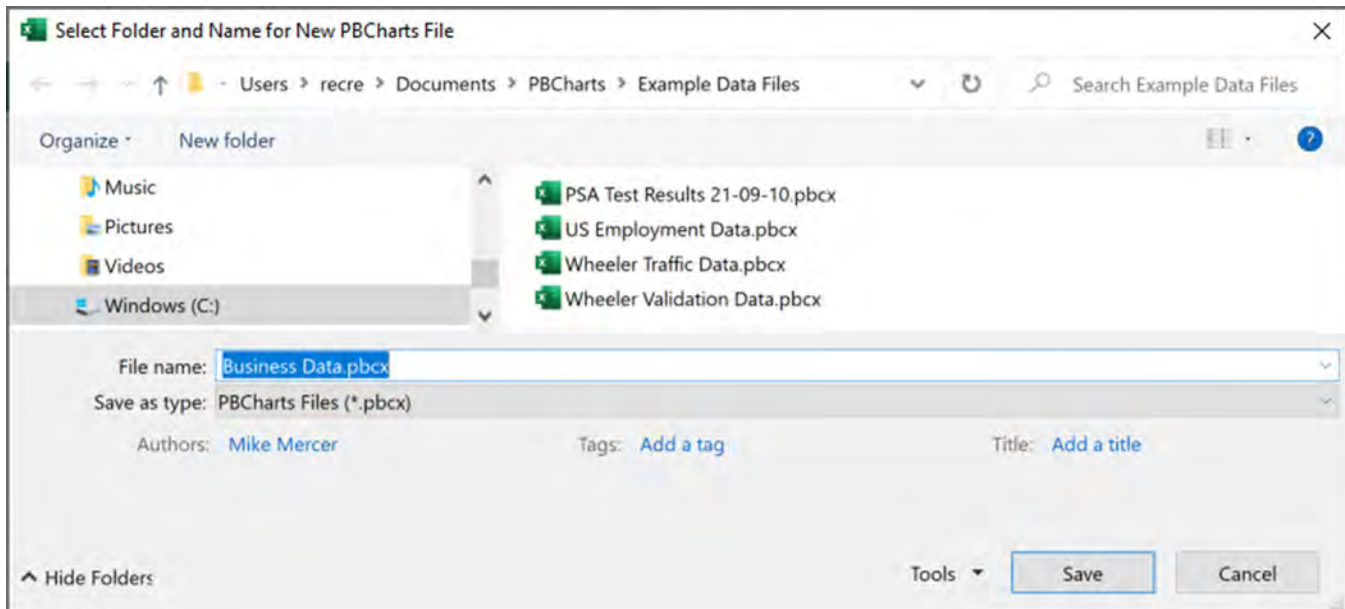


Figure 3.12 - Selected Data Imported into PBChart

CREATING A BLANK PBCHARTS FILE



When you are working in another application containing data, such as a data base or a web page and would like to use the PBCharts add-in to analyze the data you can create a blank PBCharts file to paste the data.

Donald Wheeler has published an article "Traffic Deaths Down for the Third Straight Year", located at <http://www.spcpress.com/pdf/DJW157.pdf>.

At the bottom of page 1 is a table of data that can be copied and pasted and structured into a Minitab File.

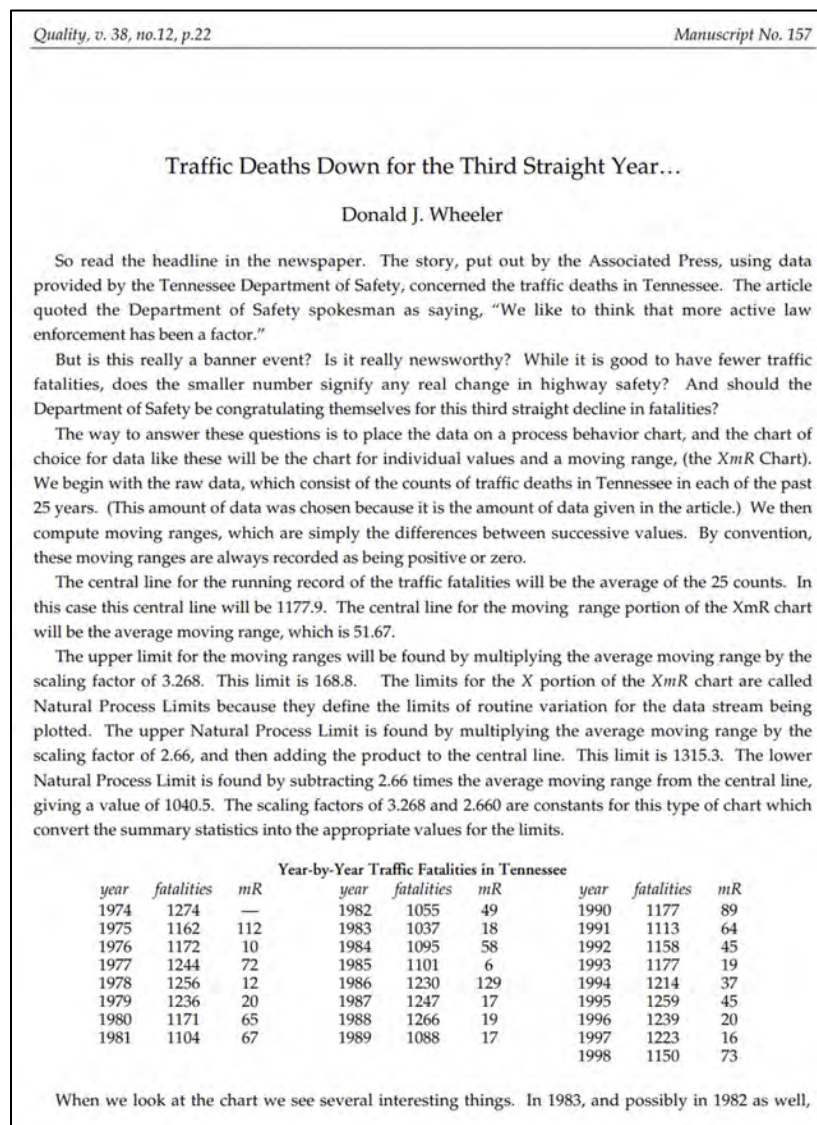
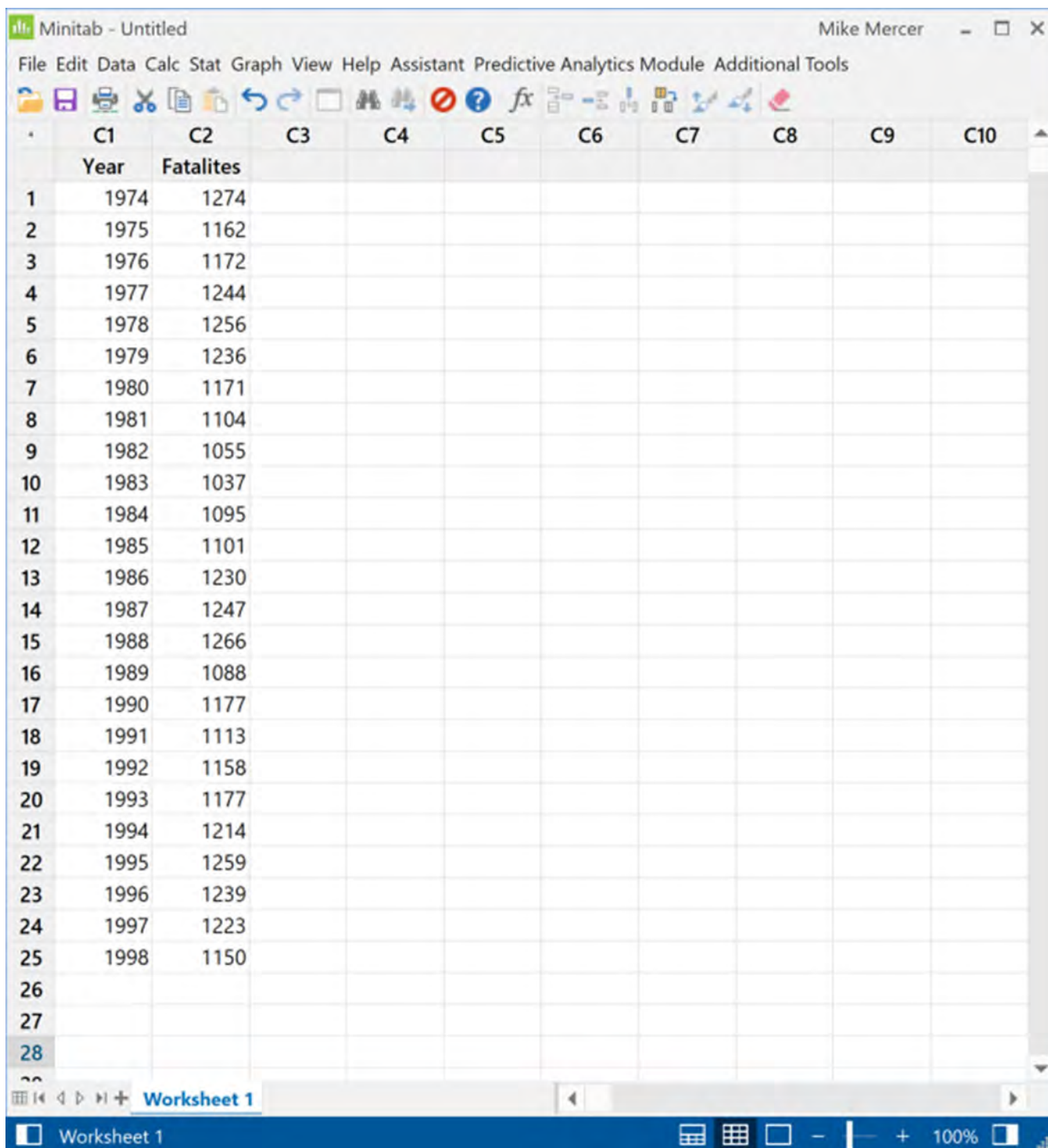


Figure 3.13 - Wheelers Traffic Death Article

The data was copied and organized in Minitab, a well-known statistics program.



	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	Year	Fatalites								
1	1974	1274								
2	1975	1162								
3	1976	1172								
4	1977	1244								
5	1978	1256								
6	1979	1236								
7	1980	1171								
8	1981	1104								
9	1982	1055								
10	1983	1037								
11	1984	1095								
12	1985	1101								
13	1986	1230								
14	1987	1247								
15	1988	1266								
16	1989	1088								
17	1990	1177								
18	1991	1113								
19	1992	1158								
20	1993	1177								
21	1994	1214								
22	1995	1259								
23	1996	1239								
24	1997	1223								
25	1998	1150								
26										
27										
28										

Figure 3.14 - Minitab with Wheelers Traffic Data

Copy the data from Minitab and go to PBCharts in Excel .

Press the “**Blank PBCharts File**” icon and go to the “[Documents/PBCharts](#)” folder and enter “**Wheelers Accident Data**” then press Save.

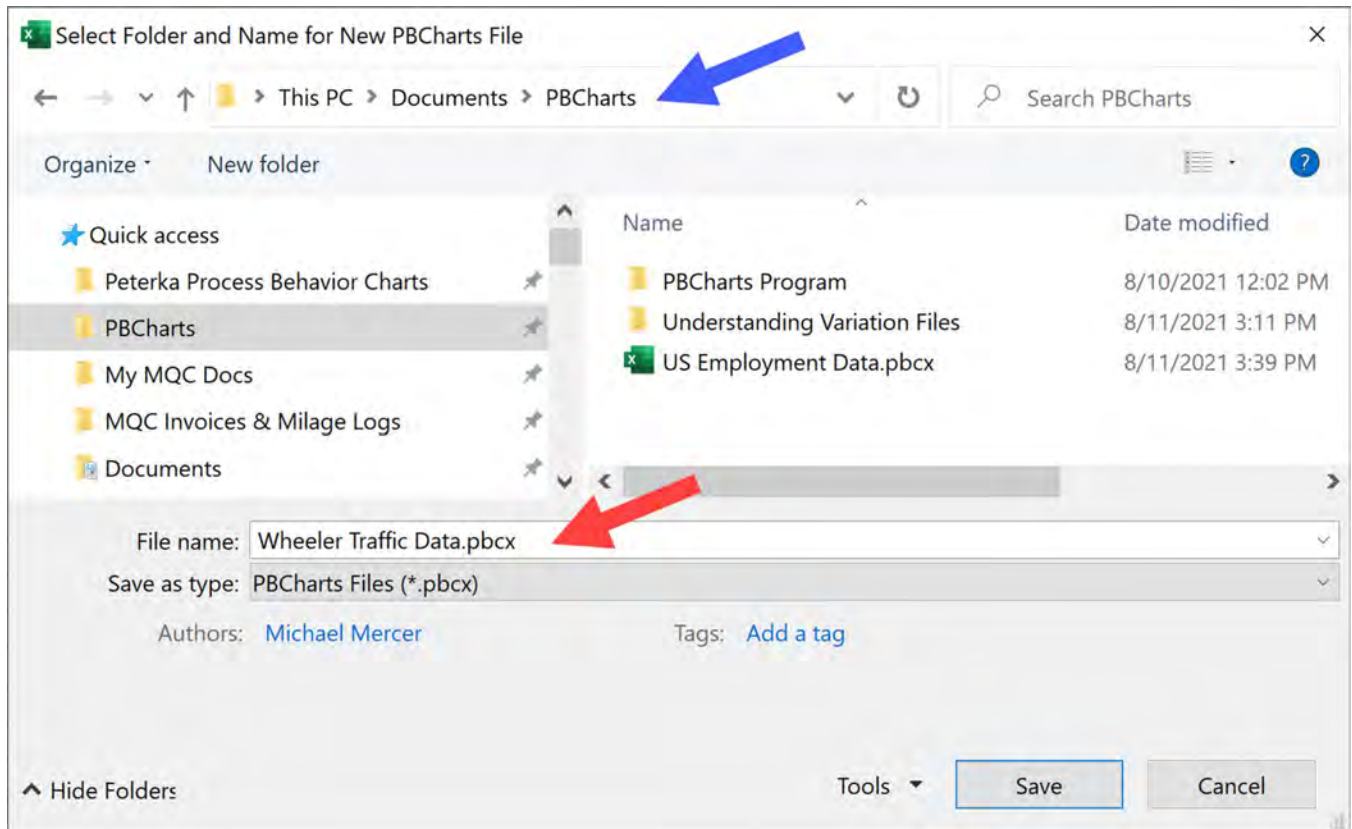


Figure 3.15 - Creating a Blank PBCharts File.

The “Wheeler Accident Data.pbcx” file has been created and is awaiting pasting of the data. Place your cursor in cell A1 and paste the data

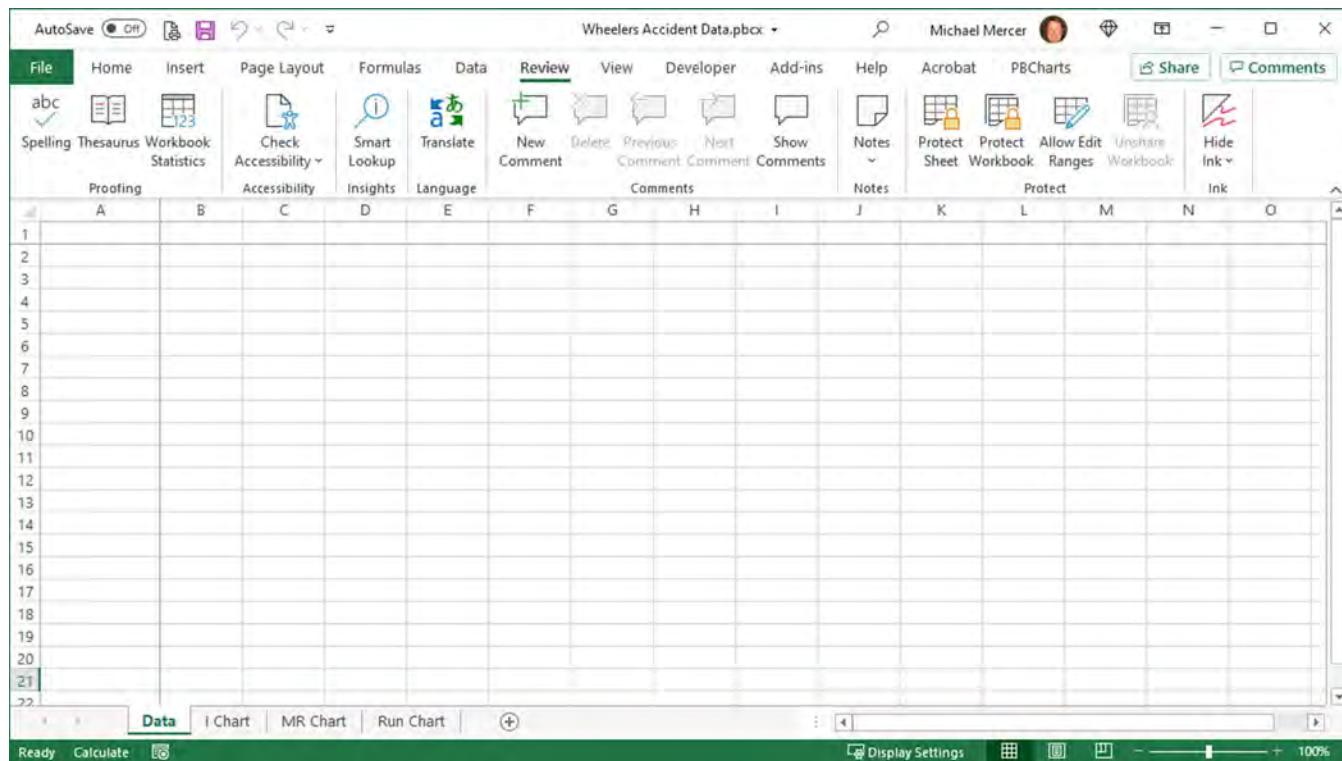


Figure 3.16 - PBChart ready for data

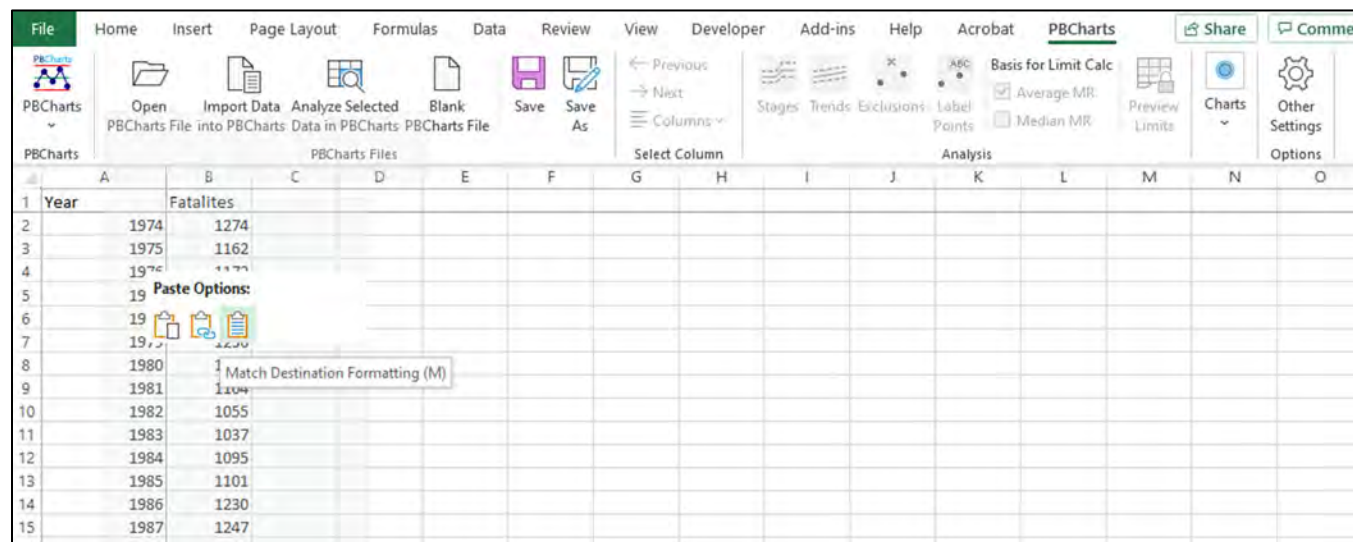


Figure 3.17 - Pasted Data from Minitab

The following chapter will describe in detail how to create an I-MR Chart, but here is what the chart looks like. “Traffic Deaths Down for the Third Straight Year...” So read the headline in the newspaper. Here is what Dr. Wheeler had to say when he viewed the data in the form of a process behavior chart.

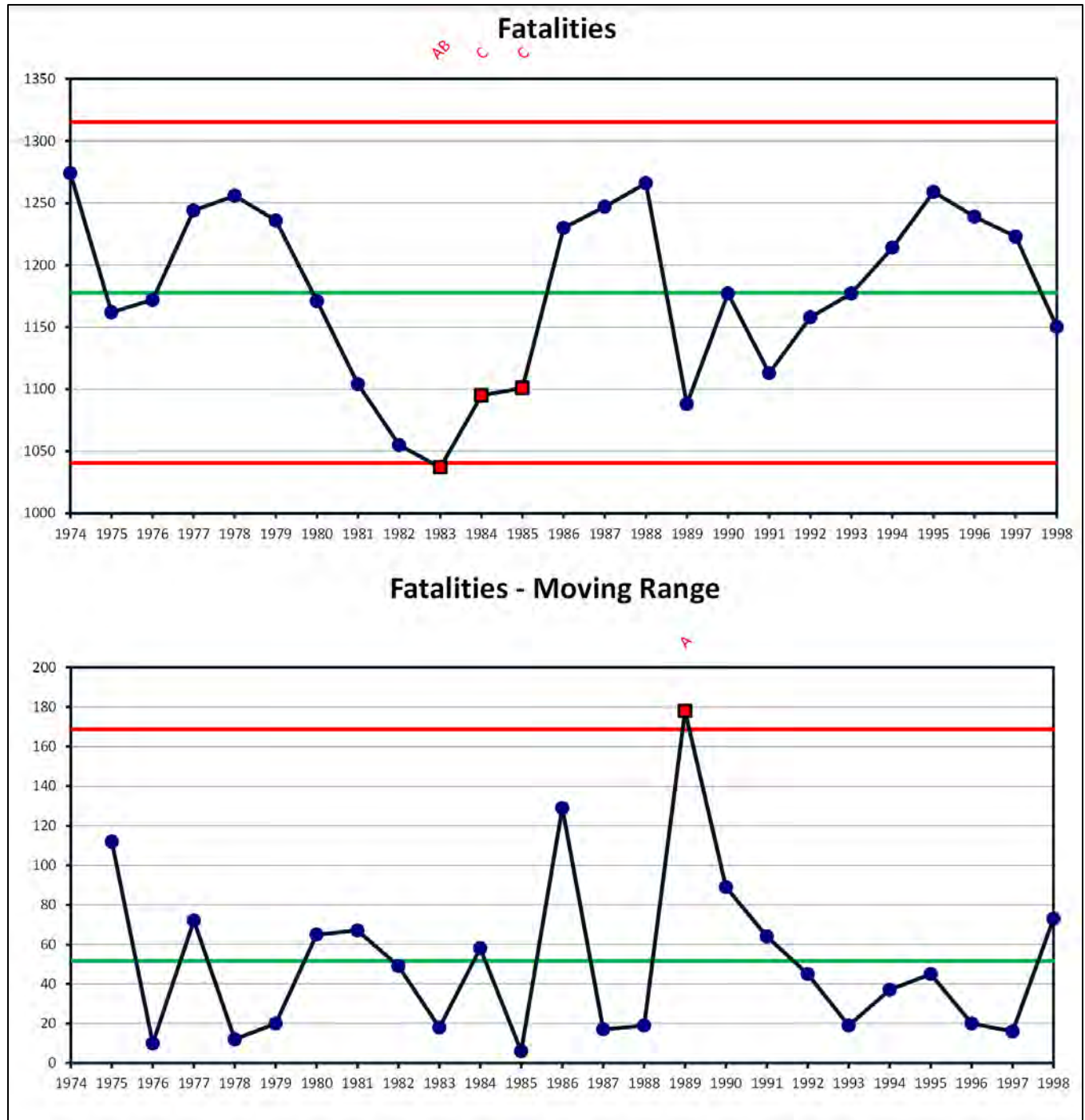


Figure 3.18 - I-MR Chart

“When we look at the chart, we see several interesting things. In 1983, and possibly in 1982 as well, something was happening to reduce the number of traffic fatalities. ...the number of traffic deaths in 1983 was enough smaller than this average to warrant looking for an explanation.

Also, the dramatic drop in traffic deaths between 1988 and 1989 was larger than is likely to have occurred by chance. This is indicated by the moving range value that exceeds the upper limit on the moving range portion of the chart. It would be appropriate to seek an explanation of this change, because it does not appear to be routine variation.

Finally, the third straight decline in the number of traffic fatalities heralded in the headline does not appear to signify anything unusual happening. It is well within the bounds of routine variation and does not constitute an abnormal pattern. After all, there were four straight increases before the last three declines!

SAVE AND SAVE AS PBCHARTS FILE BUTTON



Both the “**Save**” and “**Save As**” icons save files with a pbcx filename extension. “**Save**” saves the open file with the current filename. “**Save As**” allows you to save the file with a different filename and with the pbcx filename extender.

File

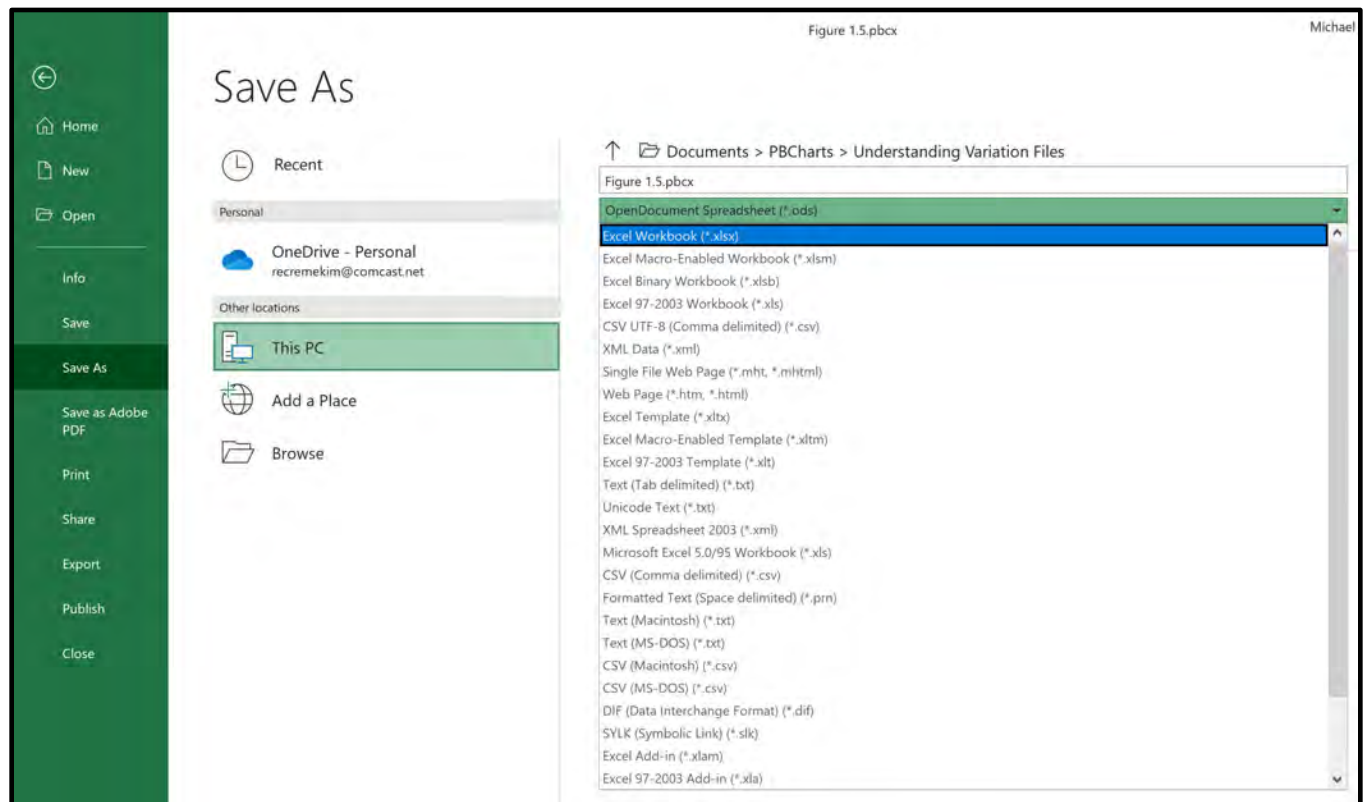
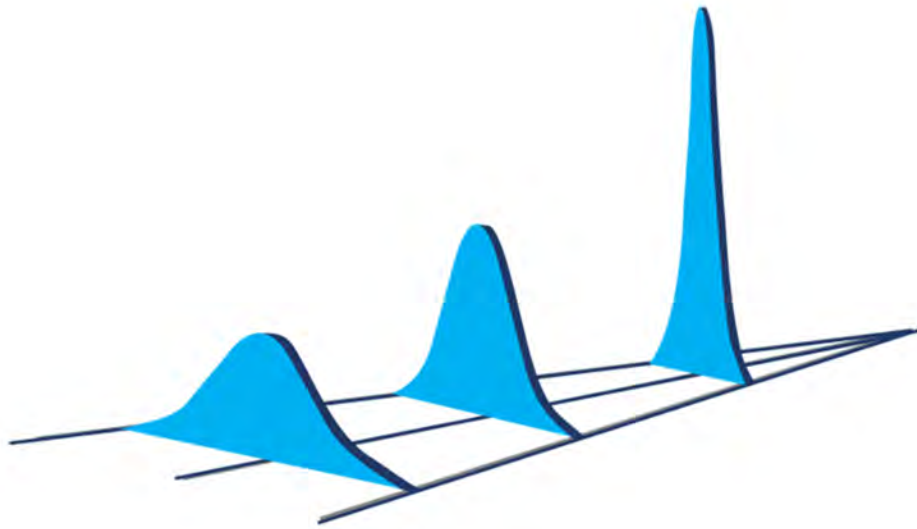


Figure 3.19 - Default Excel File Types

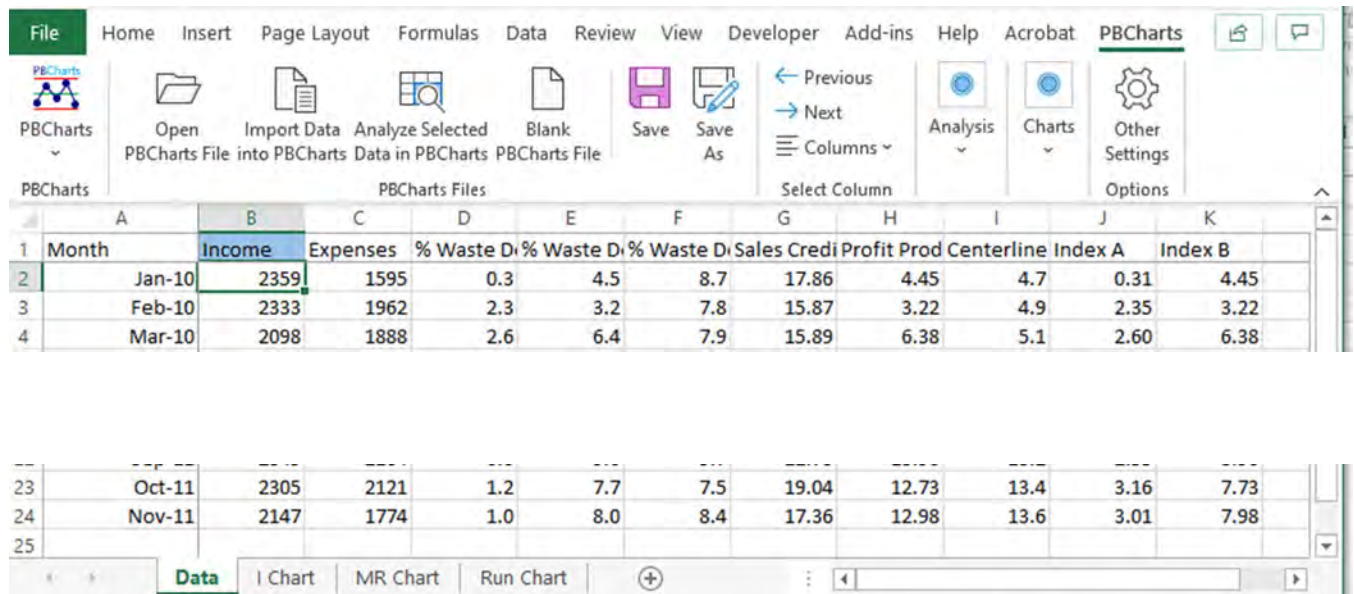


Chapter 4

FIVE CHARTS

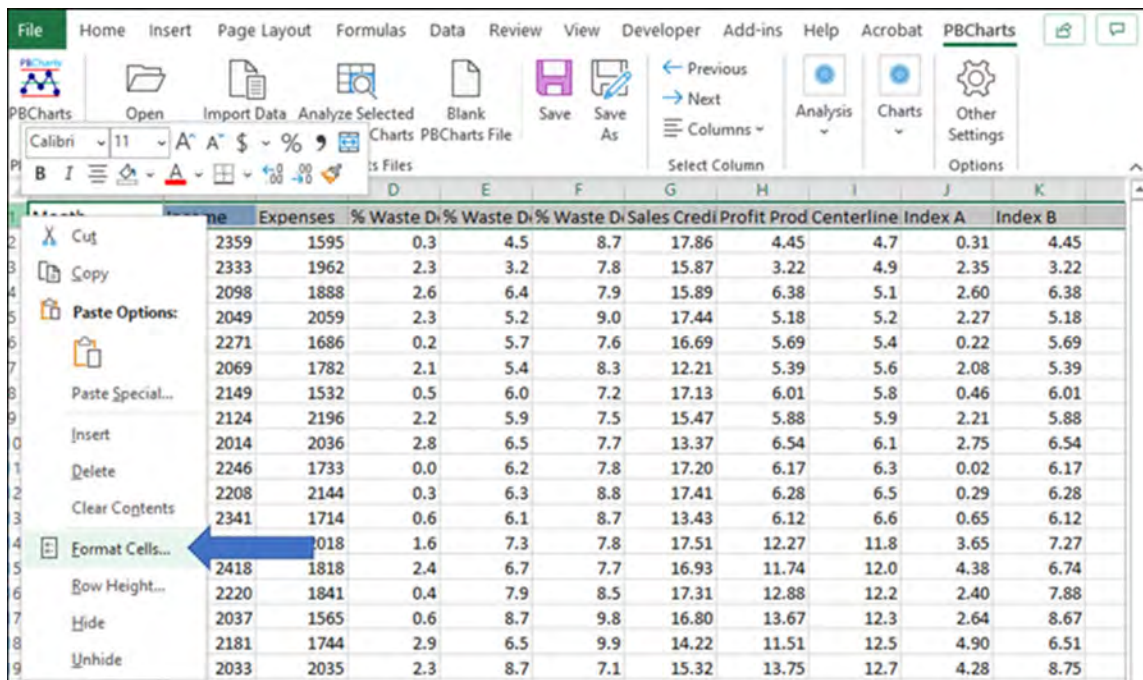
In the last chapter we showed many ways to open data files. What they all had in common was that they saved the data in a default PBChart file format with a pbcx filename extender. The pbcx file structure not only saves the data but also any customizations you make to the charts.

Open the file “**Business Data.pbcx**” file located in the “**Documents/PBChart/Example Data Files**” directory.

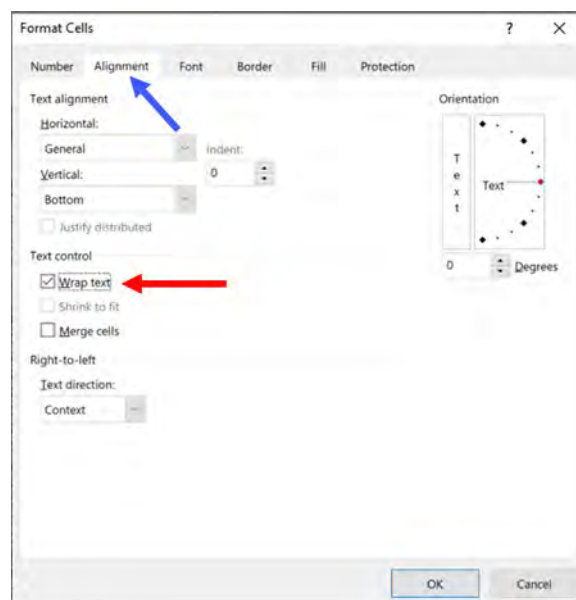


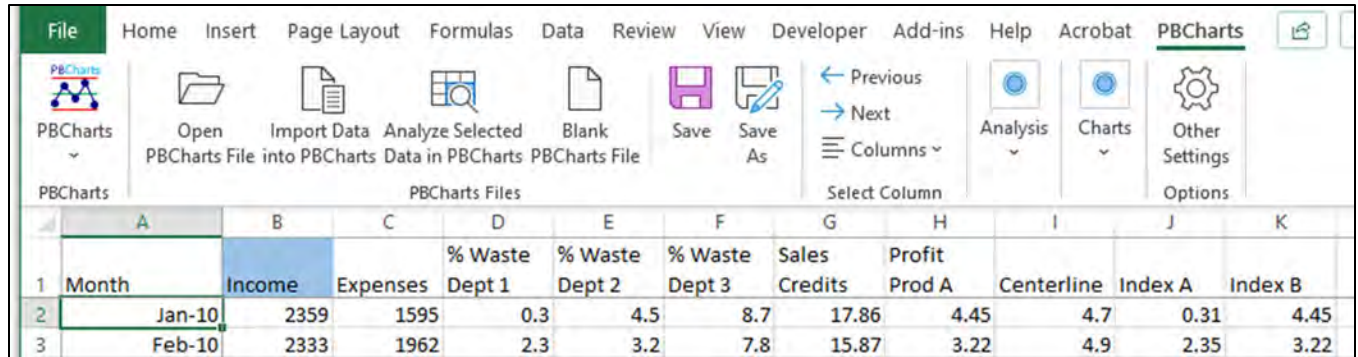
	A	B	C	D	E	F	G	H	I	J	K
1	Month	Income	Expenses	% Waste D	% Waste D	% Waste D	Sales Credi	Profit Prod	Centerline	Index A	Index B
2	Jan-10	2359	1595	0.3	4.5	8.7	17.86	4.45	4.7	0.31	4.45
3	Feb-10	2333	1962	2.3	3.2	7.8	15.87	3.22	4.9	2.35	3.22
4	Mar-10	2098	1888	2.6	6.4	7.9	15.89	6.38	5.1	2.60	6.38
23	Oct-11	2305	2121	1.2	7.7	7.5	19.04	12.73	13.4	3.16	7.73
24	Nov-11	2147	1774	1.0	8.0	8.4	17.36	12.98	13.6	3.01	7.98
25											

The first thing to notice is that Row 1 is not formatted to wrap the text, so the names of the columns are partially hidden. Place your cursor outside row 1 and right click to select the entire row then select “[Format Cells](#)”.



Go to the “[Alignment](#)” tab and check the “[Wrap text](#)” checkbox.





Notice in Figure 4.4 the column **"Income"** is highlighted in blue; the blue color indicates which column will be displayed on a Chart Worksheet tab. Use the **"Previous"** and **"Next"** icons in the **"Select Column"** Group or select the appropriate column from the **"Columns"** icon.

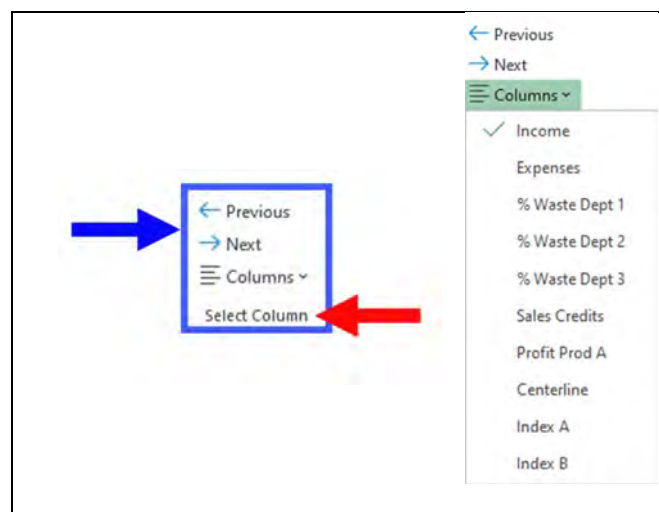


Figure 4.5 - Select Columns

It is not our purpose to discuss or review the fundamentals of Control Chart theory nor is it our intention to bother you with the appropriate formulas for computing limits and centerlines. A wonderful reference for further study is Wheeler's book. (Wheeler, Understanding Variation the Key to Managing Chaos, 2000)

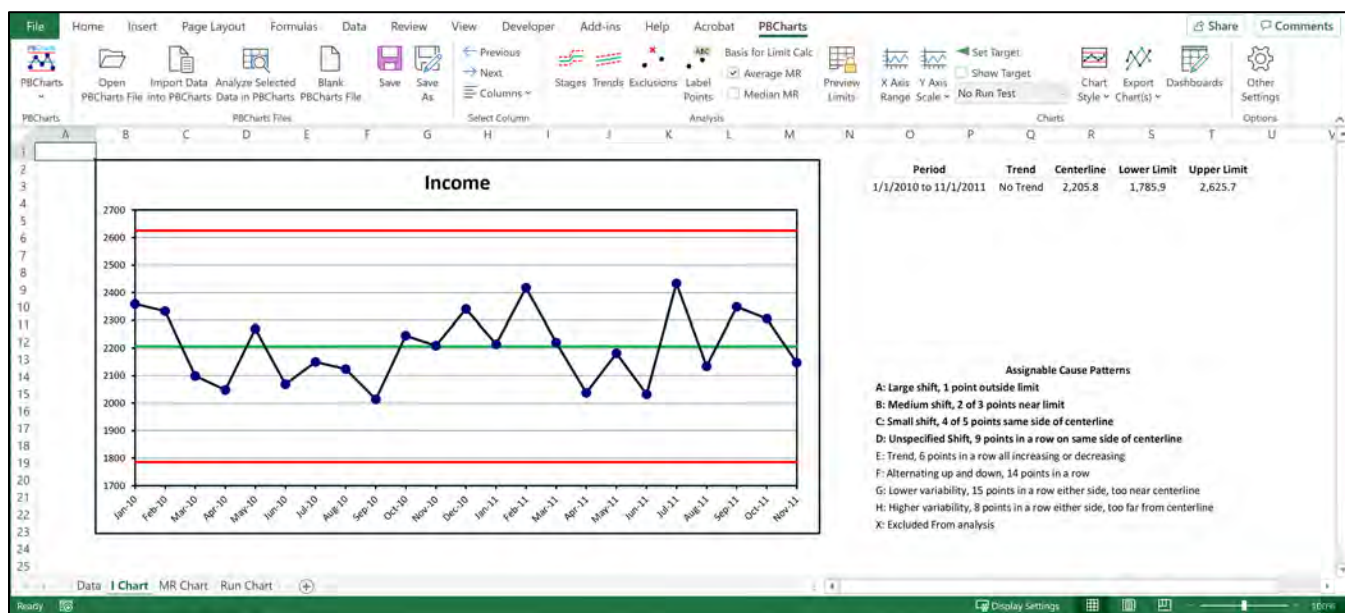
Rather it is our purpose to identify those control chart features that our software supports.

INDIVIDUALS CHART (I CHART)

Select the “I Chart” worksheet tab at the bottom of the app.



Figure 4.6 - Select the I Chart worksheet tab



There are three separate figures on the I Chart Tab:

1. The **I Chart** – a time series plot of equally spaced individual data points with lines for the Upper and Lower Natural Process Limits. We will explore tools to edit charts on the Analysis and Charts Ribbon Menu Tabs in Chapter Five and Six.
2. **Parameter Table** containing the period, and values for centerline and limits. If there are different stages, there will be an entry for each stage.
3. **Assignable Cause Patterns** showing the currently enabled codes in **bold**. Use the Other patterns. Chapter Eight shows how to select Special Cause Pattern Codes for the I Charts and the MR Charts.

MOVING RANGE CHART (MR CHART)

Select the “MR Chart” worksheet tab at the bottom of the app.

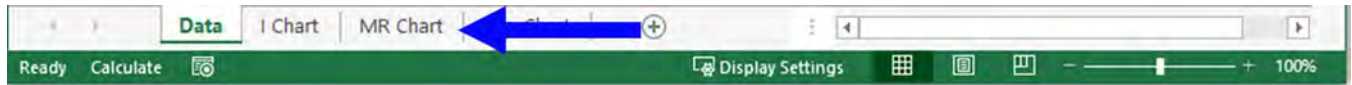


Figure 4.8 – Selecting the MR Chart Worksheet

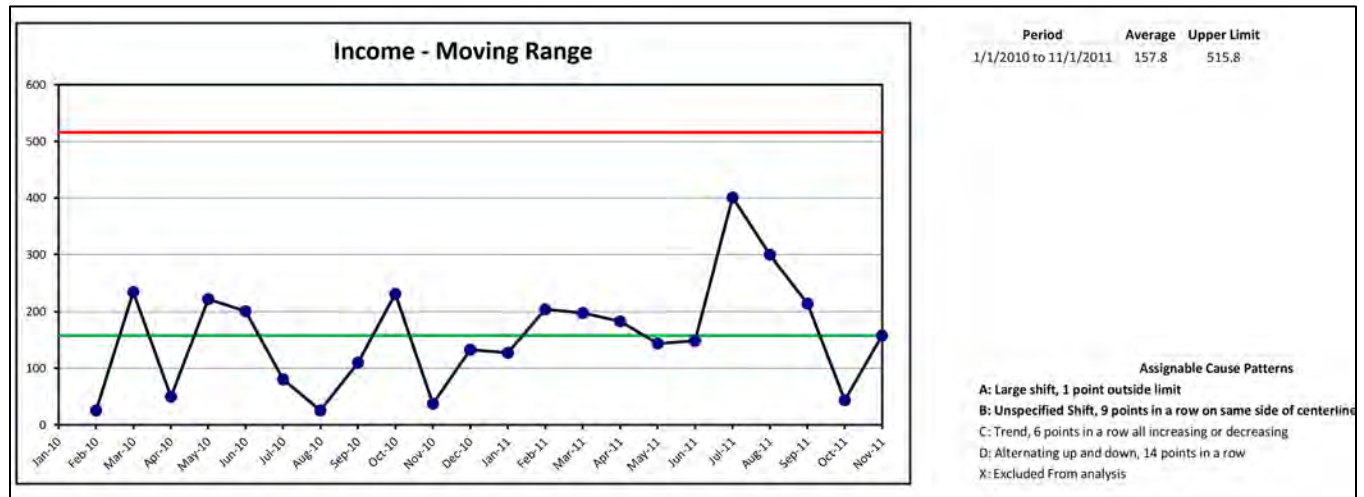


Figure 4.9 – Moving Range Chart

The MR Chart data is composed of the positive values of successive difference of the data shown on the I Chart. The positive successive difference is called a Moving Range, it's just the positive difference of one data point to another. It is the most under rated chart of them all. The average moving range and the median moving range are proportional to the standard deviation of the data. The standard deviation is used to compute the natural process limits of the I Chart as well as the upper limit on the MR Chart.

RUN CHART

Select the Run Chart worksheet tab at the bottom of the app.



Figure 4.10 - Selecting the Run Chart

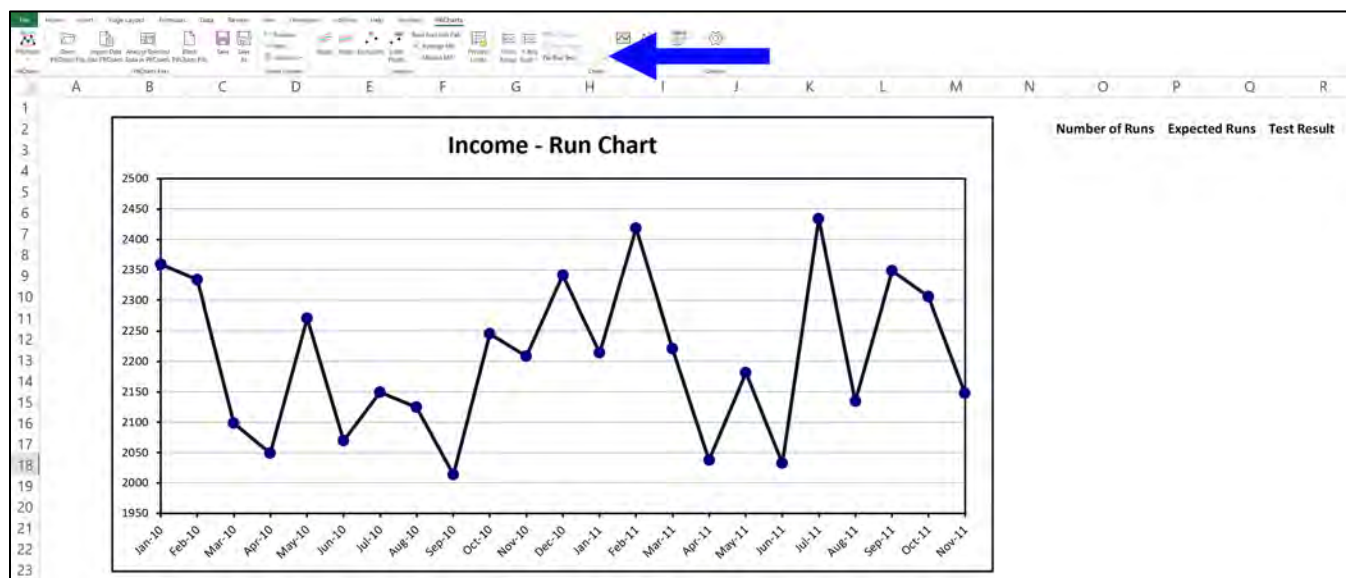


Figure 4.11 - Run Chart

The Parameter Table is blank until a Runs test is selected. The blue arrow in Figure 4.11 is pointing to the icon where you can select either a “Runs About Median” test or a “Runs Up or Down” test.

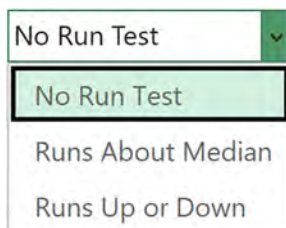


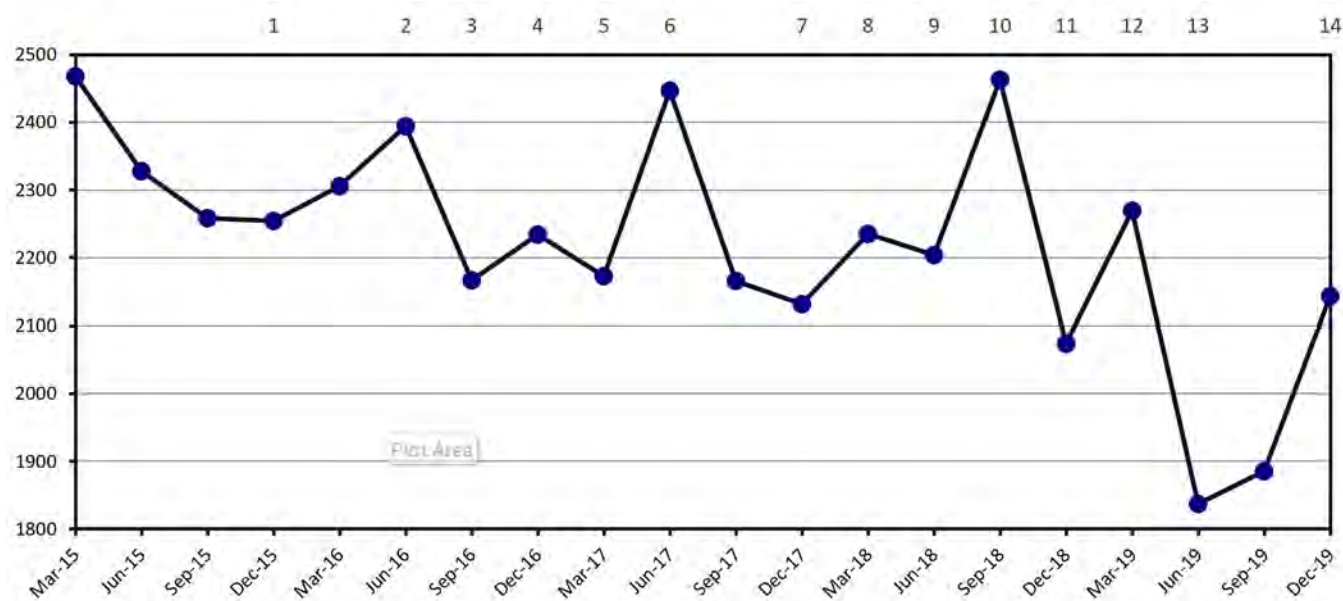
Figure 4.12 Runs Test Combo Box

The results of the test will show up in the Parameter table. The runs test is further described in Chapter Six.

Runs About Median	Expected Runs	Clustering/Mixture Test
12	12 (8 to 17)	Neither
Runs Up or Down	Expected Runs	Trends/Oscillations Test
17	15 (12 to 18)	Neither

Figure 4.13 - Runs Test Parameter Tables

When a runs test is selected the runs are enumerated at the top of the Run Chart, Figure 4.14 has identified 14 Runs Up or Down.



I-MR CHART

An I-MR Chart contains both the I Chart and the MR Chart. It is available as a selection in the Charts group using the “[Dashboards](#)” tool.

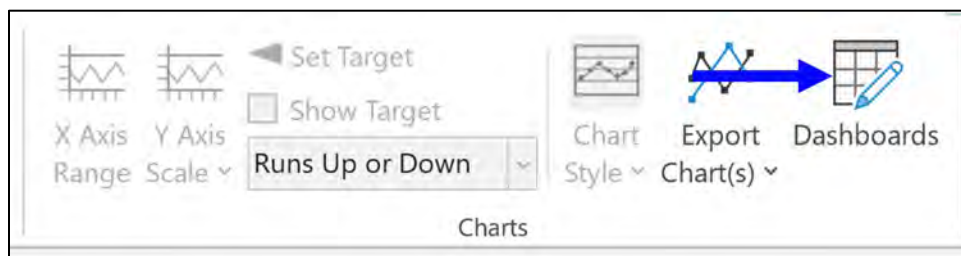


Figure 4.15 - Pathway to I-MR Chart

Once the I-MR Chart is created with the Dashboards Tool it is displayed in a named worksheet tab, such as “[Income I MR Chart](#)”. Chapter Seven will describe how to use the Dashboards Tool to make I-MR Charts.

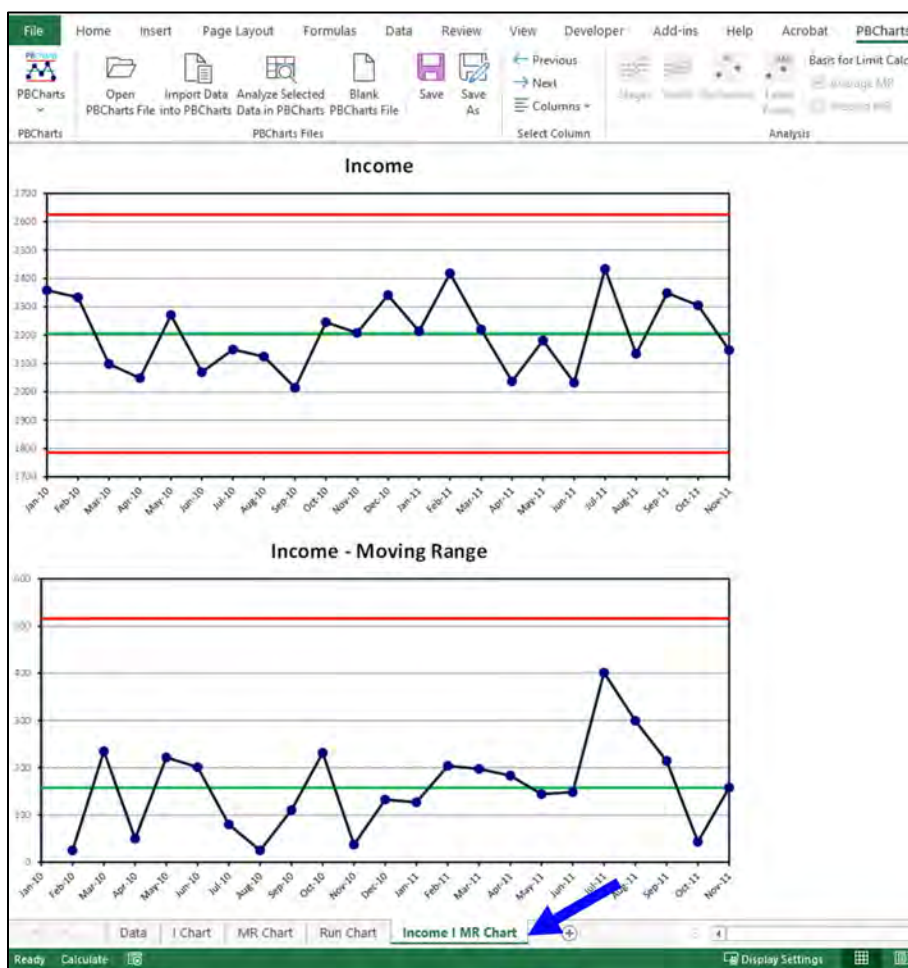


Figure 4.16 - Custom I MR Chart

DASHBOARDS

The fifth type of chart is the Dashboard which can display as many charts that you care to place on one page. Figure 4.17 displays a custom Dashboard with the title “[KPIs for Acme Manufacturing](#)”

Dashboard creation is covered in depth in Chapter Seven.

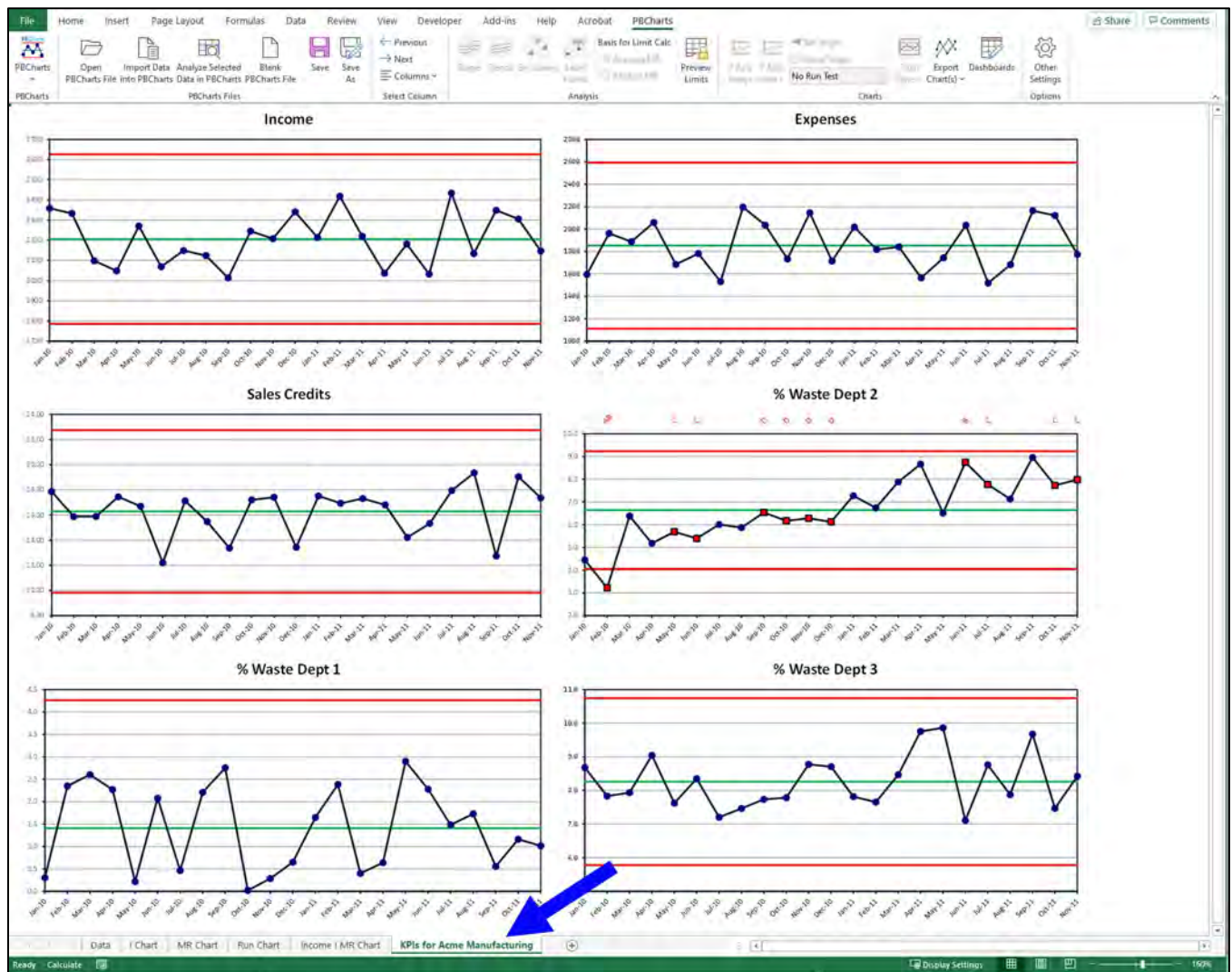


Figure 4.17 - Custom Dashboard

When you print a dashboard, the Dashboard Title “KPIs for Acme Manufacturing” prints at the top of the page. It’s a reminder that it’s always a good idea to save and name each dashboard.

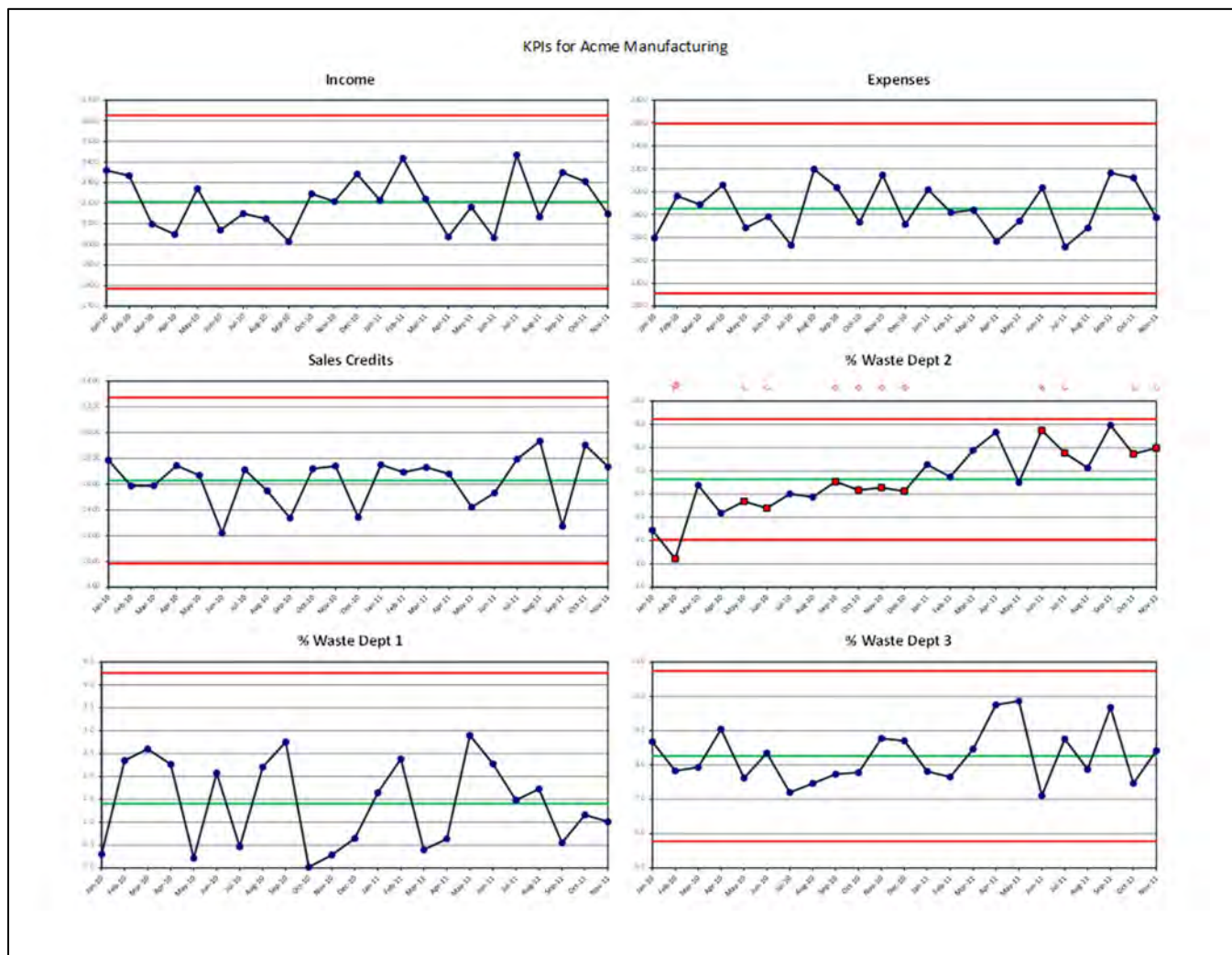
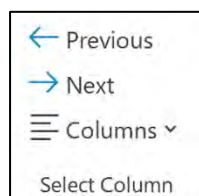


Figure 4.18 - Excel Print Output

SELECT COLUMN GROUP



The “**Select Column**” group allows one to move from one data column to another, forward or backward using the arrows. Also, you can press the “**Columns**” icon to select a specific column, see Figure 4.19.

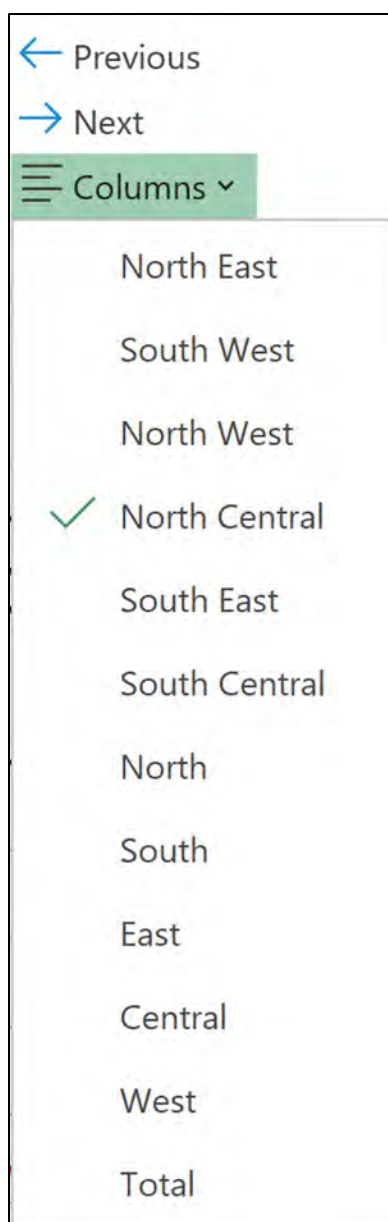


Figure 4.19 Selecting a Specific Data Column

PBCHARTS WORKFLOWS

In the prolog we stated that PBCharts may be used in two different ways, to diagnose performance or to monitor and manage. Each has a separate workflow and I'll describe these workflows further here.

DIAGNOSTIC

When we want to know what happened in the past to determine an improvement program, we employ PBCharts in a diagnostic manner.

A large amount of past data is assembled and viewed on an I Chart and the MR Chart. Look at the MR Chart first for Assignable Cause Patterns, then look for Assignable Cause Patterns on the I Chart. If there are no Assignable Cause Patterns identified on either chart, then we say the process is predictable and we can estimate future performance in a specific manner. We can predict the average value and the plus or minus a range the predicted value will lie in. For instance, given the Key Performance Indicator (KPI) Income, see Figure 4.7, we can predict Income will average 2206 thousand dollars plus or minus 420 thousand dollars per month. Now we can judge the acceptability of these values. Does the average meet our goal? Is the variability of the KPI too much? If improvement is needed, we start an Improvement program to make major changes to the system. Only a system wide change can impact a predictable process.

What if we find Assignable Cause Patterns in the I Chart or the MR Chart? We use the tools in the PBCharts Analysis group i.e. Stages, Trends, and Exclusions to model the data. Chapter 5 will describe these tools in detail. Finding the reasons for the Assignable Cause Patterns in the I and MR Charts will be the basis of this Improvement program. We want to find out the reasons so that we can prevent them in the future. For instance, if the data showed two or more stages where the value of the KPI shifted, we should try to find the reason for the shift, so that we can possibly apply the finding to improve the system.

MONITORING AND MANAGING

When we want to monitor a KPI we look at the most recent data, that is predictable i.e. free of Assignable Cause Patterns. Usually, 12 to 24 data points are a good starting point. If there is an occasional Assignable Cause Pattern in this grouping, we use the exclude tool in the PBCharts Analysis group. Next, we lock the average and limits on the charts, so that ongoing addition of data does not change the limits. When ongoing data is added we respond only to Special Cause Patterns. This eliminates a lot of time and effort wasted in the futile search for common cause reasons that plague management meetings.

Chapter 5

ANALYSIS GROUP

The “**Analysis**” group contains six icons that are used to model the data.

STAGES

This chapter will explore when the I Chart and MR Chart benefit with stages and trends. A stage represents a predictable period where the natural process limits are computed from just the data within that stage. Sometimes people create stages for each year which is not recommended. Generally, a stage captures a predictable period where there were no assignable causes impacting the data.

Sometimes there are data that show a trend, such as sales of a product with year over year sales increases. Steady progress can be modeled with a linear trend line. Exponential trends can model startups such as Facebook Revenue¹, see Figure 5.1.

The chart below has two stages, the first stage shows an exponential trend for Facebook’s early startup revenue, then from 2015 forward the second stage shows a linear trend which is quite admirable. The year 2014 was a transition year where growth changed from exponential to linear.

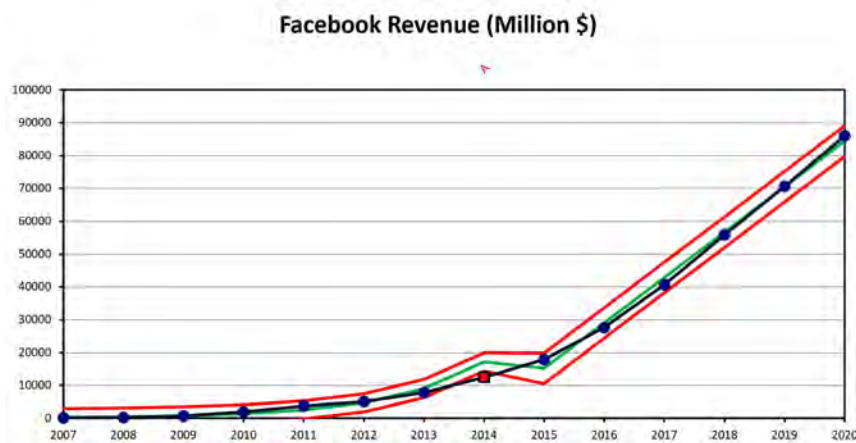


Figure 5.1 Facebook Revenue

AIRLINE DATA - STAGES

Stages represent statistically significant shifts in the mean. We included step changes in PBChart. Change-Point software is available to statistically identify mean shifts. Taylors Change-Point Analyzer² is an example. Most users can adequately eyeball stages.

Import File “**On-Time Airline Data.xlsx**” and press the I Chart Tab, note all the special causes. Two stages are readily apparent. Choose Dec-98 as the start of the second stage.

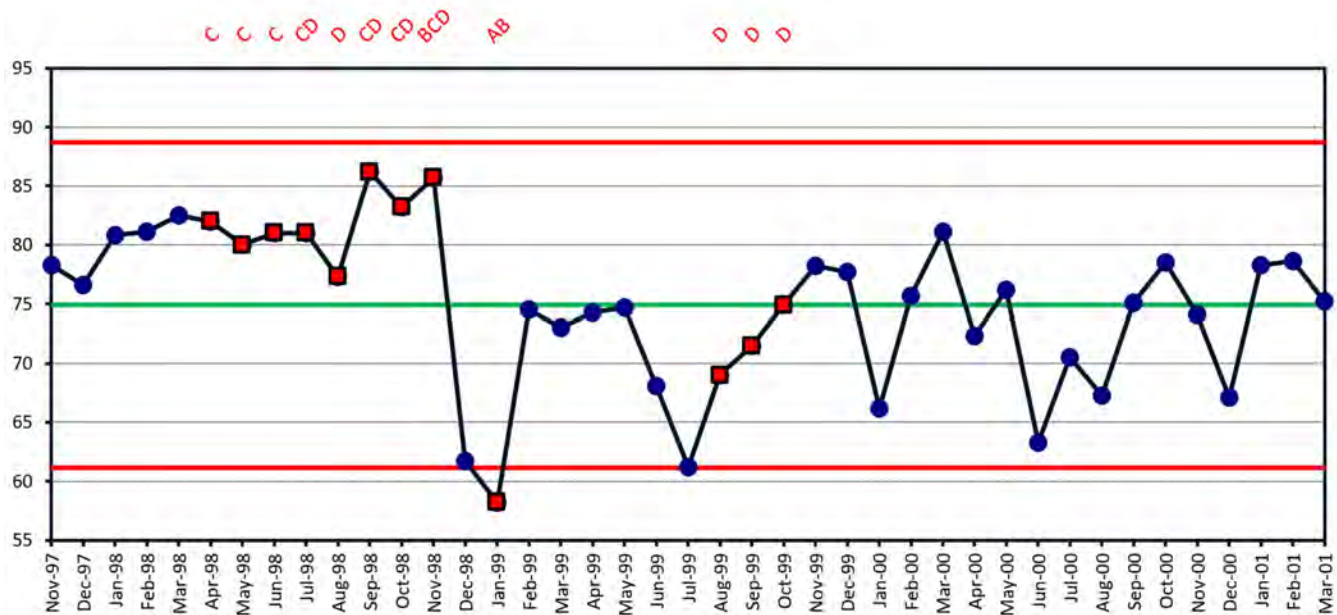


Figure 5.2 On-Time Airline Data

To insert a stage, press the “[Stages](#)” icon in the “[Analysis](#)” group

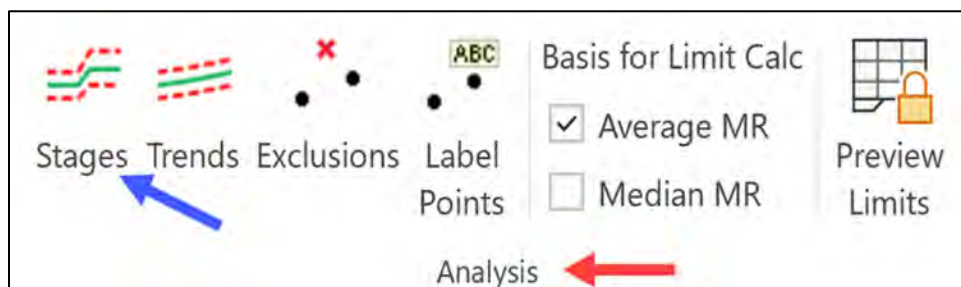


Figure 5.3 Stages button

When the “Manage Stages Analysis” dialog opens, check “Dec-98” then press “**Apply Changes**”, then “**Done**”.

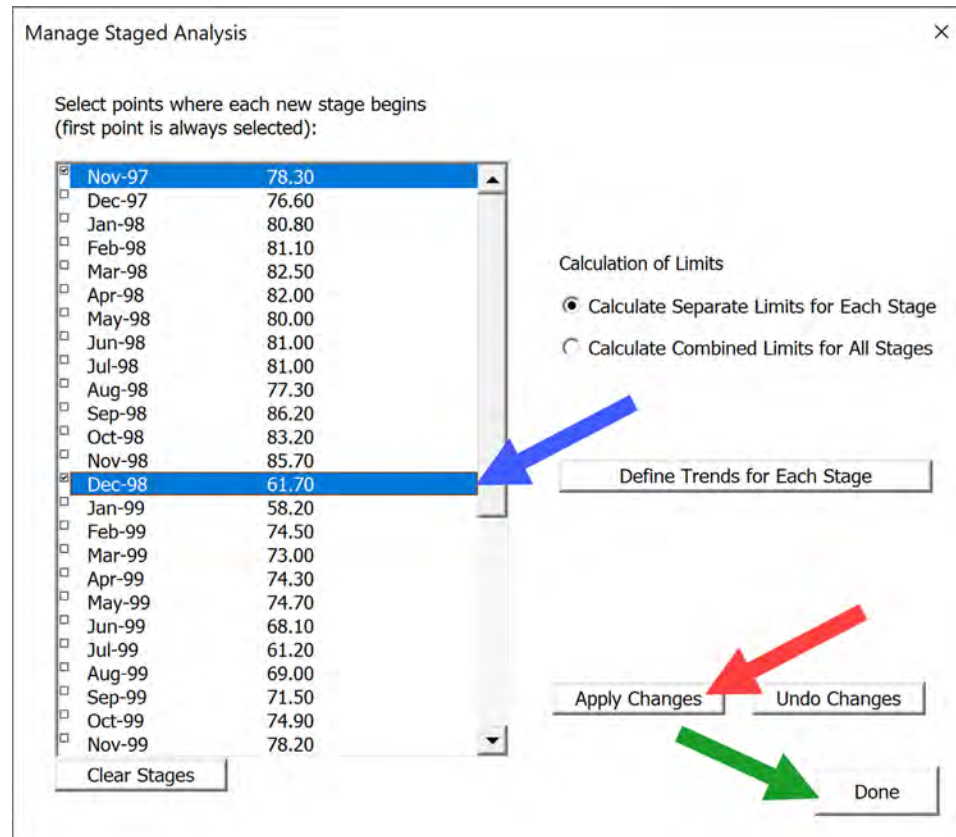


Figure 5.4 Selecting the start of a new stage

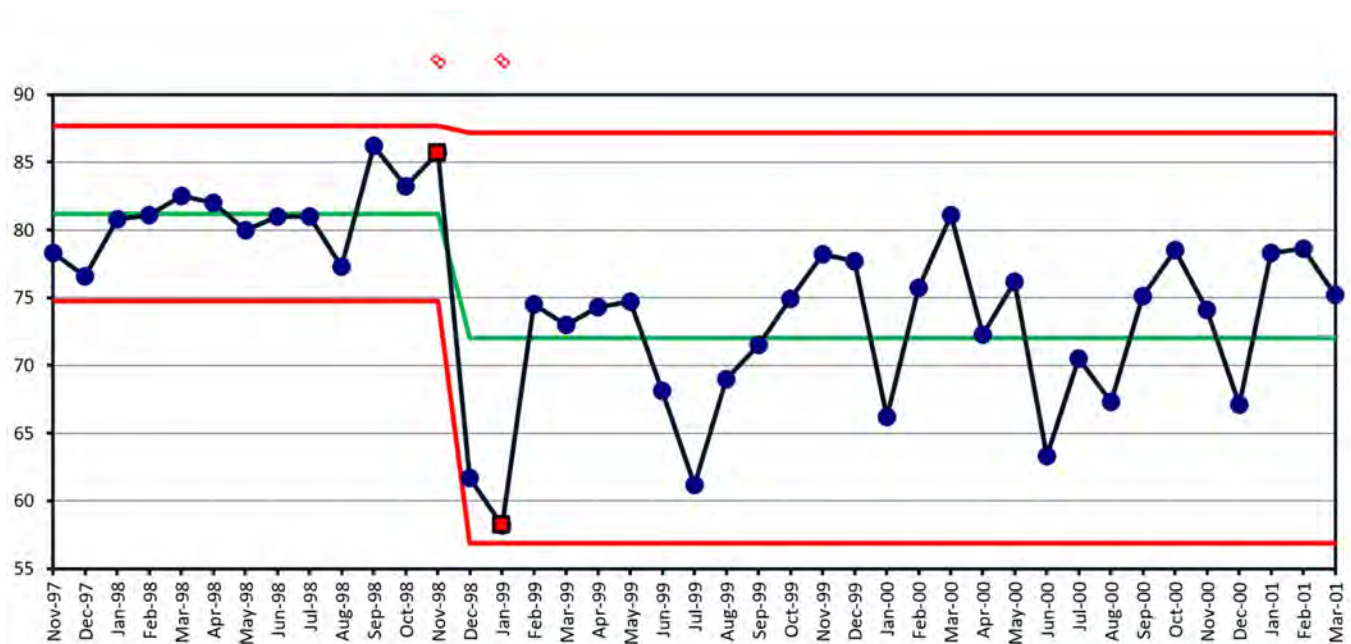


Figure 5.5 Airline data with two stages.

There are “Medium Shift” special causes identified by the letter code (B) at the end of first stage and the beginning of the second stage.

Model the data with four stages, beginning with “Sep-98”, “Dec-98” and “Feb-98”.

Press the “**Stages**” icon again and enter these values, “Sep-98”, “Dec-98” and “Feb-98”.

Because the second stage starting at Sep-98 only has three data points, and the third stage starting at Dec-98 has only two data points, it might be wiser to use the “[Calculation of Limits](#)” option and select “**Calculate Combined Limits for all Stages**”.

This option increases the effectiveness of the estimation of the natural process limits because all the data is used to estimate the limits. This works if the underlying data has uniform variability. Let’s try it and see.

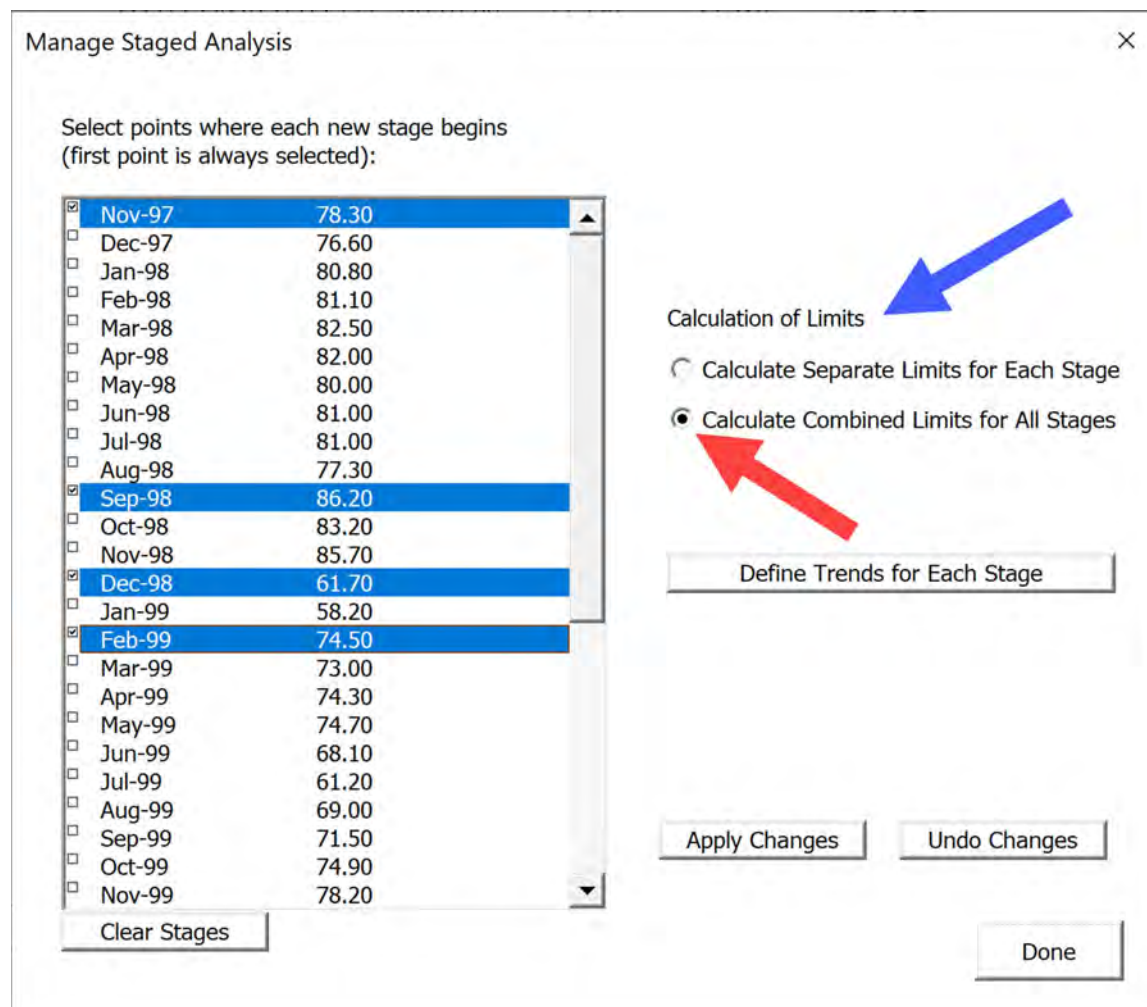


Figure 5.6 Four stages Combined Limits

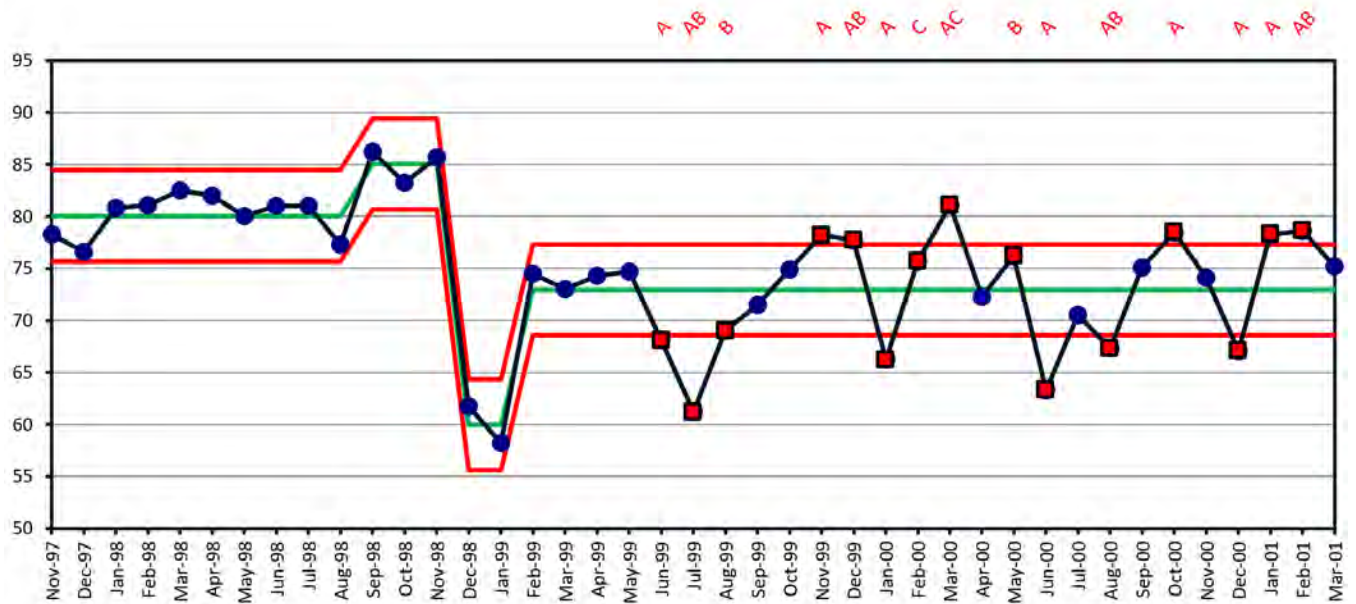


Figure 5.7 Using Combined Limits

This didn't work out as expected, the variability within the first and last stages must be significantly different. Looking at the MR chart we can see the different variability.

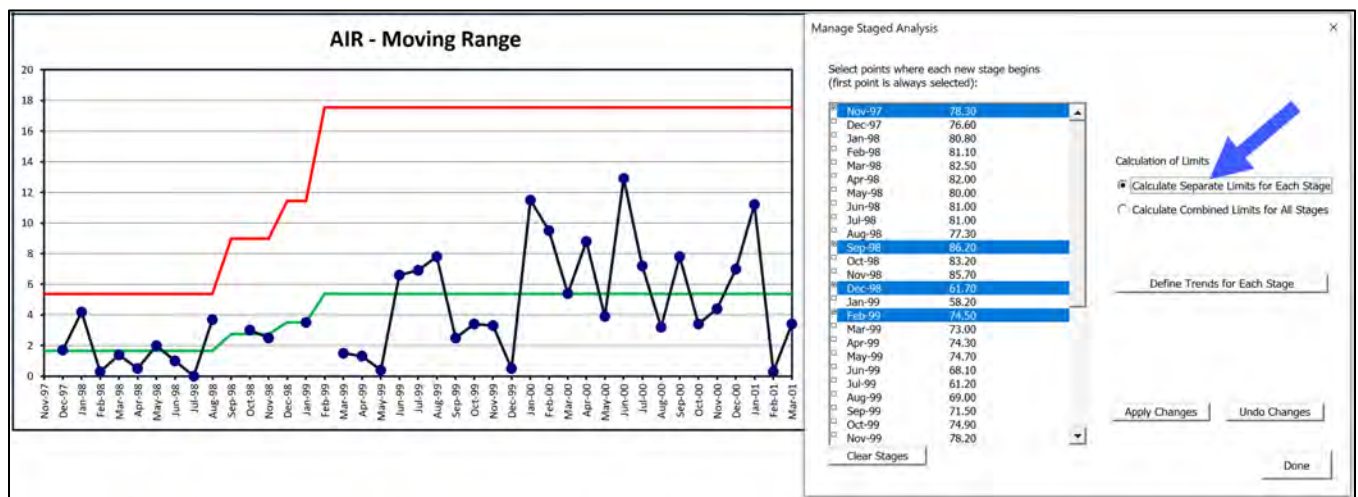


Figure 5.8 MR Chart

The variability is significantly different within each of the four stages. Reset the "Calculation of Limits" option to "Calculate Separate Limits for Each Stage"

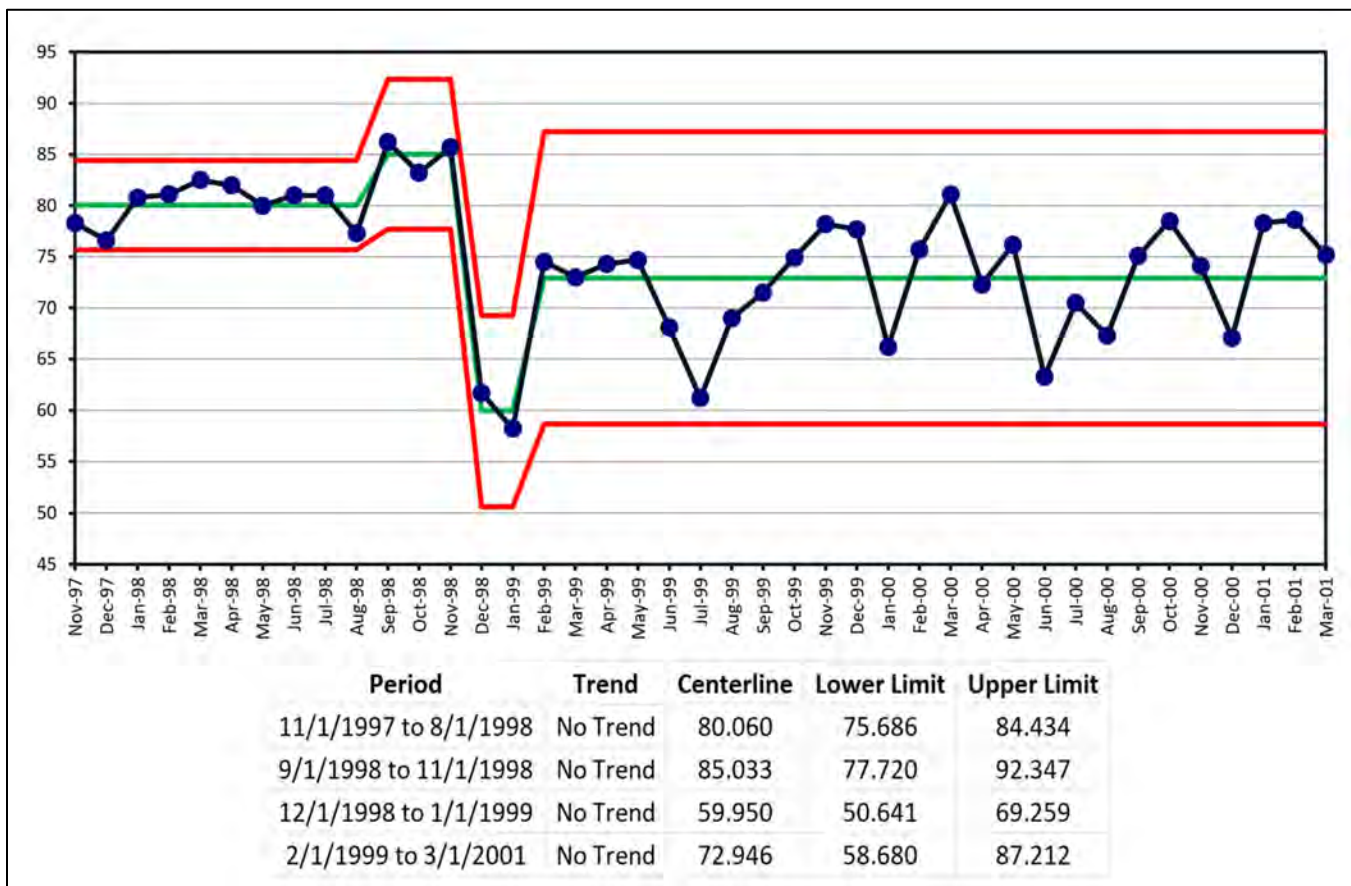


Figure 5.9 On-Time Airline data with four stages

Not only did this airline have a significant decline in performance but it's even more unreliable, which is another way of saying it displays more variability.

SALES DATA - STAGES AND TRENDS

Import the file “Sales Data by Quarter.xlsx” and press the I Chart worksheet tab.

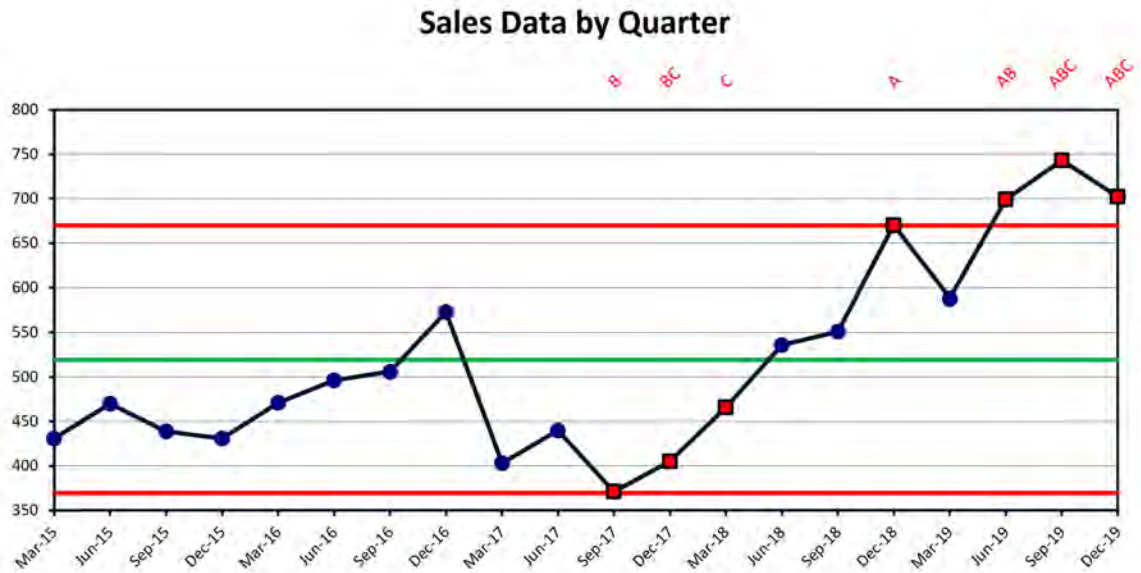


Figure 5.10 Sales data by Quarter

It might help to know that a new salesperson took over the territory starting July 2017 after retirement of the previous salesperson. Let's select "Sep-17" as the start of the second stage and model the second stage as a trend. Look at the MR Chart to see if there are any assignable cause patterns to decide on same or different limits for each stage.

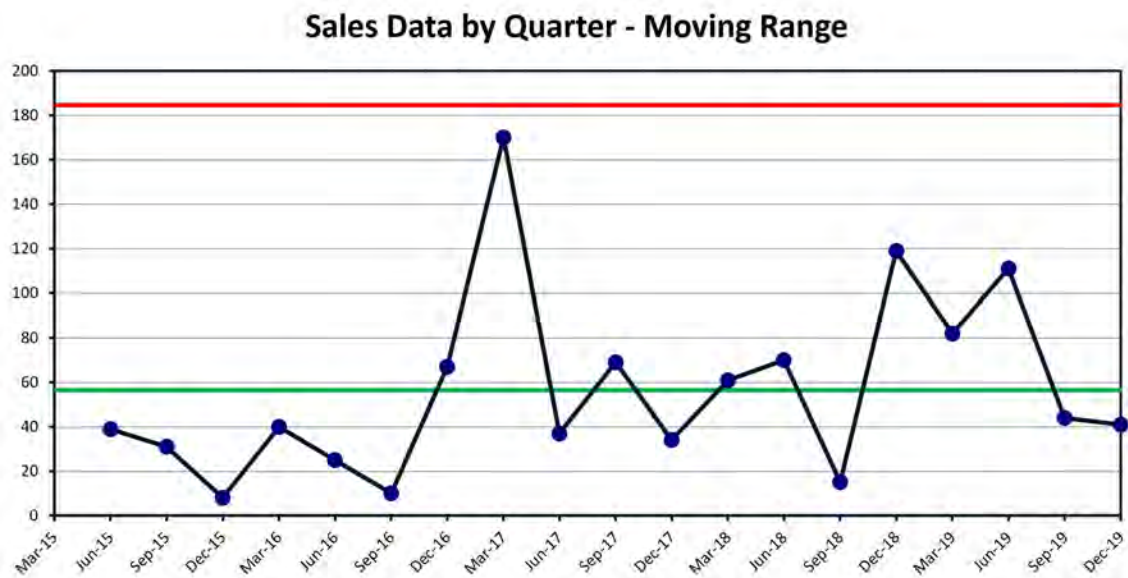


Figure 5.11 MR Chart of Sales data by Quarter.

There is no evidence of a assignable cause patterns to support different variability. Select “[Calculate Combined Limits for Each Stage](#)”, check “[Sep-17](#)”, press “[Apply Changes](#)” then press the “[Define Trends for each Stage](#)” button.

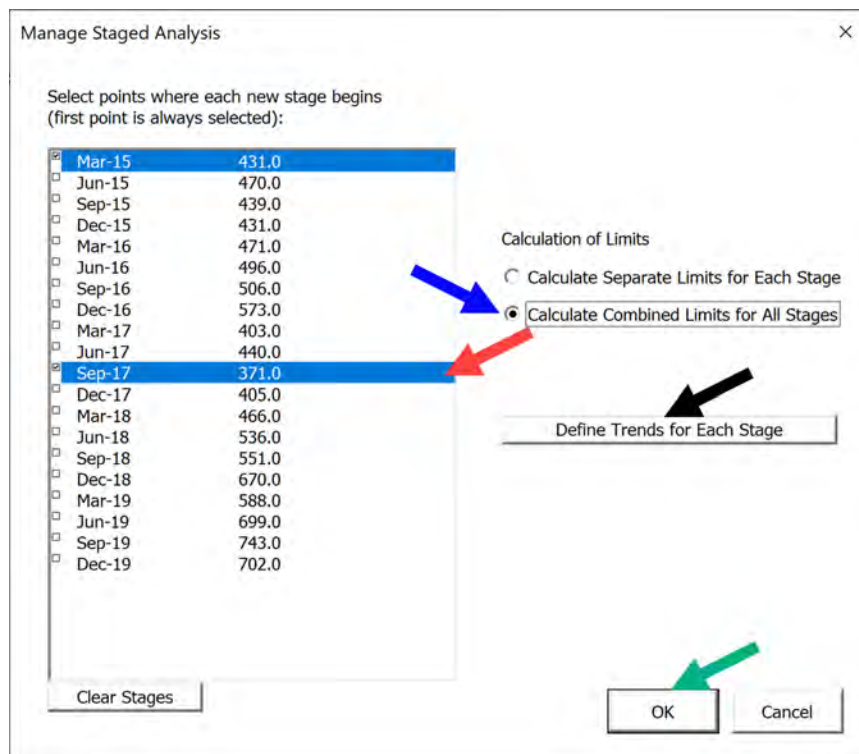
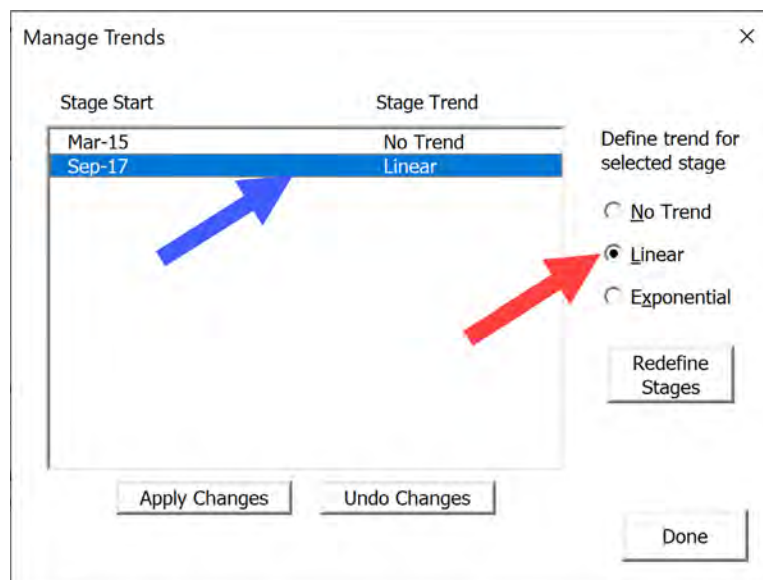


Figure 5.12 Defining Trends for Stages

Select the “[Sep-17](#)” Stage and then check the “[Linear](#)” button.



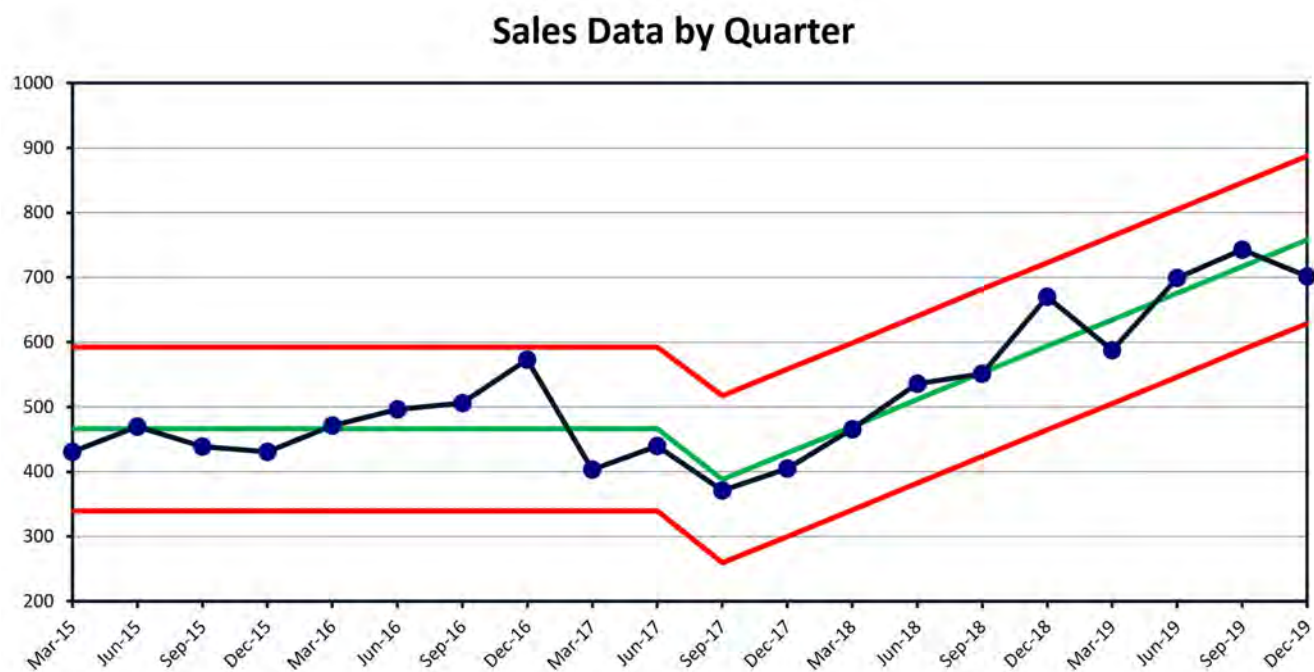


Figure 5.14 Two Stages, One with a Linear Trend.

STAGES - ADDITION OF DATA

Import File “**On-Time Airline Data.xlsx**”. Adding new data is easy, just add new dates to the Month column, see Figure 5.15. Before adding data to the data column, look at the I Chart in Figure 5.16.

	A	B
1	Month	Airline Data
40	Jan-01	78.3
41	Feb-01	78.6
42	Mar-01	75.2
43	Apr-01	
44	May-01	
45	Jun-01	
46	Jul-01	
47	Aug-01	
48	Sep-01	
49	Oct-01	
50	Nov-01	
51	Dec-01	
52		

Figure 5.15 Adding Additional Dates

Adding only dates to the first column extends the limits on charts. This is how you create forecasts, adding to the date column alone.

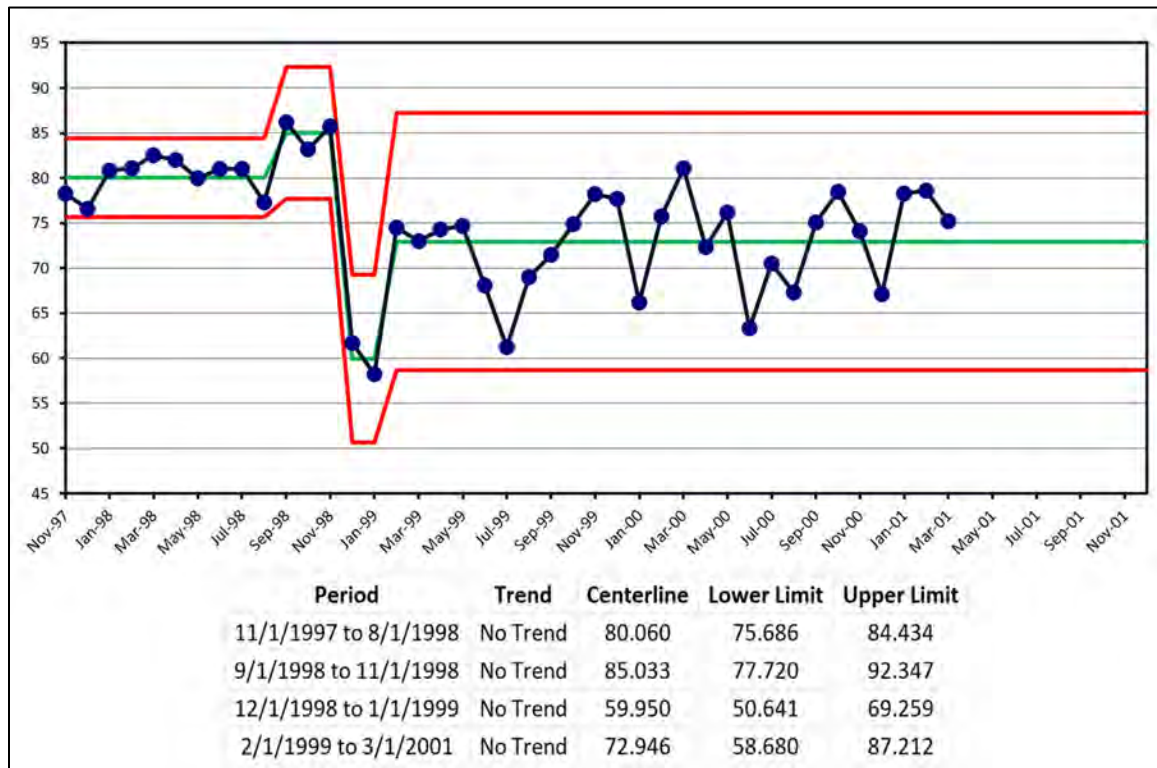


Figure 5.16 Extending the limits for forecasting

The natural process limits are extended with the same values as previously estimated, compare Figure 5.9 On-Time Airline data with four stages with Figure 5.16, the limits are the same.

	A	C
1	Month	Airline DataThe rest of the story
40	Jan-01	78.3
41	Feb-01	78.6
42	Mar-01	75.2
43	Apr-01	82.3
44	May-01	86.2
45	Jun-01	73.3
46	Jul-01	80.5
47	Aug-01	77.3
48	Sep-01	85.1
49	Oct-01	88.5
50	Nov-01	84.1
51	Dec-01	77.1
52		

Figure 5.17 Adding new On-Time Data

Whenever new data is added the last stage natural process limits change since they are not locked; they float with every new data point that is added.

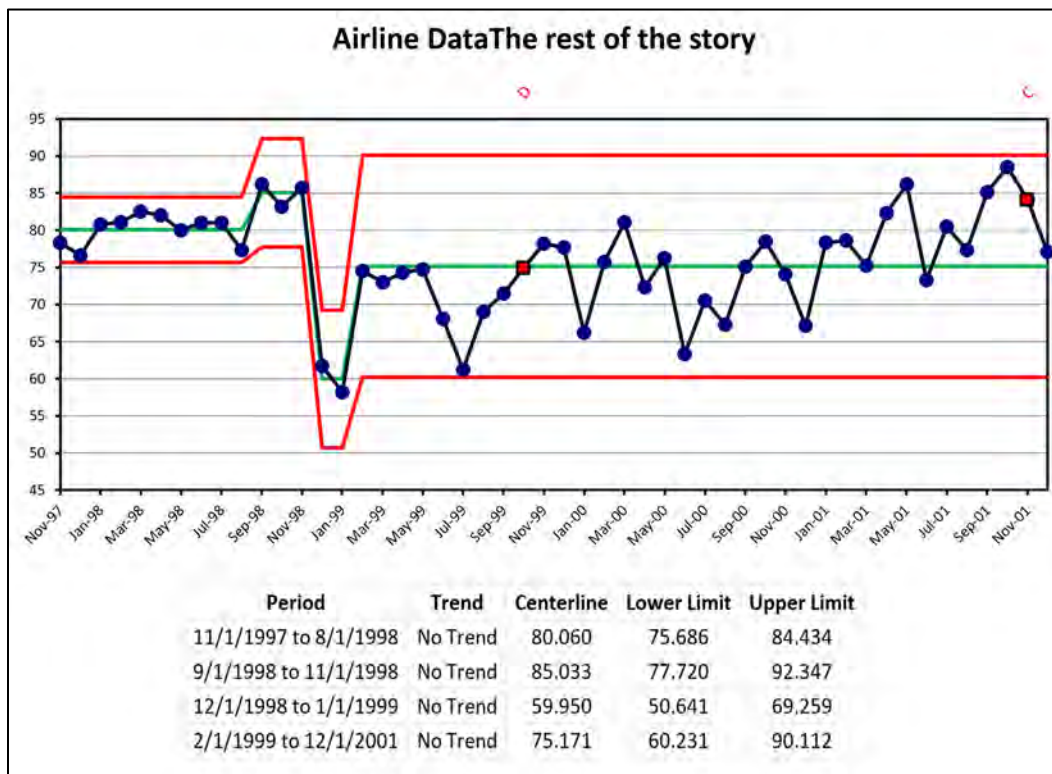


Figure 5.18 Last Stage Limits Float with Addition of New Data

EXCLUDING ASSIGNABLE CAUSE PATTERNS DATA

The statistical basis for excluding Assignable Cause Pattern points is to obtain a better estimate of the true common cause parameters for the I and MR Charts. Excluding Assignable Cause Pattern points on the I Chart is done to get a better estimate of the central location of the data. Excluding Assignable Cause Pattern points on the MR Chart is done to obtain a better estimate of the variability, i.e. to reduce the width of the natural process limits on both the I Chart and the MR Chart.

1. Excluding Assignable Cause Pattern points on an I Chart only changes the value of the mean centerline value. Points excluded on the I Chart are also excluded on the MR Chart since they are assumed to be non-representative of a predictable process.
2. Excluding Assignable Cause Pattern points on a MR chart directly reduces the value of the Average Moving Range which in turn will reduce the centerline and contract the natural process limits on the MR chart. I Chart limits will also shrink. Excluding a point on the MR Chart does not impact the data on the I Chart.

There is another way to compute limits by excluding points showing assignable cause patterns.

Import File “On-Time Airline Data.xlsx” again and use “Stages” to set a new stage at Dec-98. The only remaining assignable cause patterns are Pattern B indicating 2 out of 3 points are near a natural process limit. The first pattern occurs at Nov-98 and is triggered by the three points Sep-98, Oct-98 and Nov-98. The second pattern is due to Dec-98 and Jan -99.

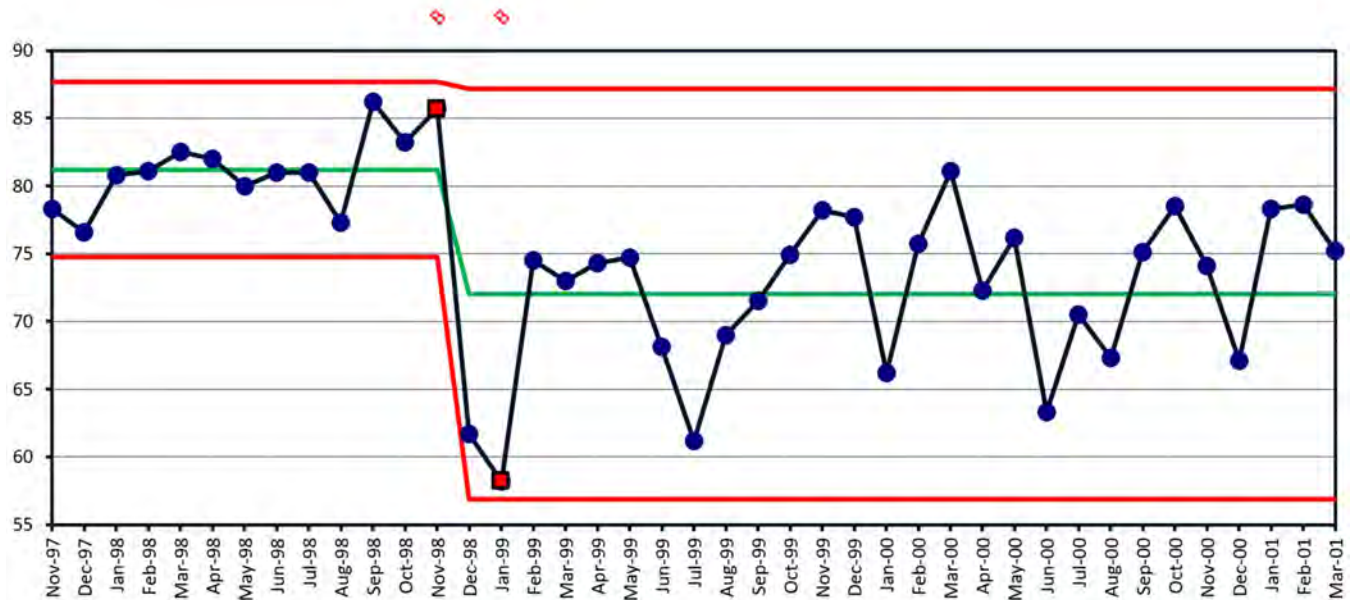


Figure 5.19 Only Two stages

Excluding the points Sep-98, Oct-98, Nov-98, Dec-98 and Jan -99 will simplify the chart. The natural process limits computed by this method, Figure 5.19 are very similar to the natural process limits computed from a more complex procedure which produced Figure 5.16”

Exclude Points

I Chart

Select values to exclude from calculation of centerline:

Clear Exclusions

<input type="checkbox"/>	Nov-97	78.30
<input type="checkbox"/>	Dec-97	76.60
<input type="checkbox"/>	Jan-98	80.80
<input type="checkbox"/>	Feb-98	81.10
<input type="checkbox"/>	Mar-98	82.50
<input type="checkbox"/>	Apr-98	82.00
<input type="checkbox"/>	May-98	80.00
<input type="checkbox"/>	Jun-98	81.00
<input type="checkbox"/>	Jul-98	81.00
<input type="checkbox"/>	Aug-98	77.30
<input checked="" type="checkbox"/>	Sep-98	86.20
<input checked="" type="checkbox"/>	Oct-98	83.20
<input checked="" type="checkbox"/>	Nov-98	85.70
<input checked="" type="checkbox"/>	Dec-98	61.70
<input checked="" type="checkbox"/>	Jan-99	58.20
<input type="checkbox"/>	Feb-99	74.50
<input type="checkbox"/>	Mar-99	73.00
<input type="checkbox"/>	Apr-99	74.30
<input type="checkbox"/>	May-99	74.70
<input type="checkbox"/>	Jun-99	68.10
<input type="checkbox"/>	Jul-99	61.20
<input type="checkbox"/>	Aug-99	69.00

Apply Changes Undo Changes

Moving Range Chart

Select values to exclude from calculation of limits:

Clear Exclusions

<input type="checkbox"/>	Nov-97	
<input type="checkbox"/>	Dec-97	1.70
<input type="checkbox"/>	Jan-98	4.20
<input type="checkbox"/>	Feb-98	0.30
<input type="checkbox"/>	Mar-98	1.40
<input type="checkbox"/>	Apr-98	0.50
<input type="checkbox"/>	May-98	2.00
<input type="checkbox"/>	Jun-98	1.00
<input type="checkbox"/>	Jul-98	0.00
<input type="checkbox"/>	Aug-98	3.70
<input type="checkbox"/>	Sep-98	
<input type="checkbox"/>	Oct-98	
<input type="checkbox"/>	Nov-98	
<input type="checkbox"/>	Dec-98	
<input type="checkbox"/>	Jan-99	
<input type="checkbox"/>	Feb-99	4.31
<input type="checkbox"/>	Mar-99	1.50
<input type="checkbox"/>	Apr-99	1.30
<input type="checkbox"/>	May-99	0.40
<input type="checkbox"/>	Jun-99	6.60
<input type="checkbox"/>	Jul-99	6.90
<input type="checkbox"/>	Aug-99	7.80

Apply Changes Undo Changes

☒ Show Excluded Points (Red "X" Marker) Apply All Changes
☐ Hide Excluded Points Undo All Changes

Done

Figure 5.20 Excluding Assignable Cause Pattern Data

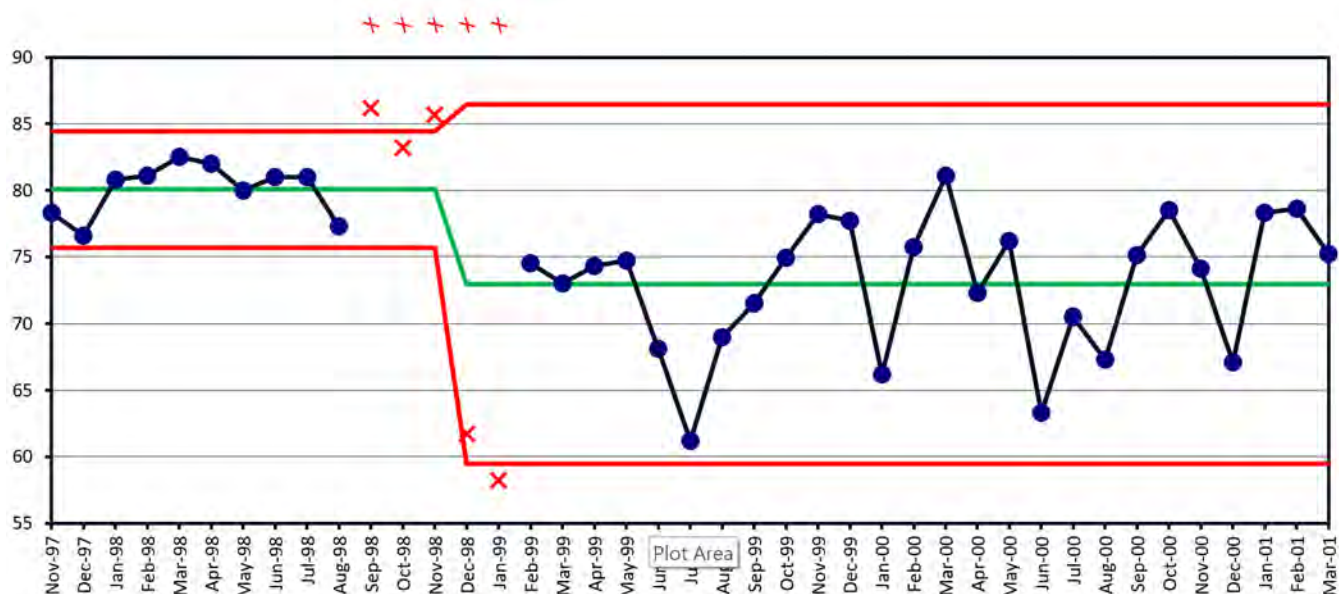
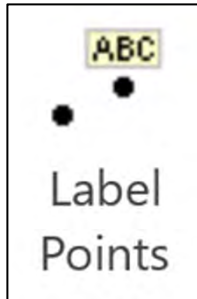


Figure 5.21 - Two Stages with Assignable Cause Pattern Data Excluded

LABEL POINTS



You can annotate an individual data point using the “**Label Points**” icon which opens the “**Labels on Charts**” dialog. Select any data point and type in “Removed Special Causes” in the “[Text Box](#)”

Labels on Charts

Select points and apply labels to charts
Labels will appear on all (I, MR, and Run) charts

Point	Data Label
Nov-97	78.300
Dec-97	76.600
Jan-98	80.800
Feb-98	81.100
Mar-98	82.500
Apr-98	82.000
May-98	80.000
Jun-98	81.000
Jul-98	81.000
Aug-98	77.300
Sep-98	
Oct-98	
Nov-98	
Dec-98	
Jan-99	
Feb-99	74.500
Mar-99	73.000
Apr-99	74.300
May-99	74.700
Jun-99	68.100
Jul-99	61.200
Aug-99	69.000

Clear All Labels

Sep-98

Removed Special Causes

Clear Apply

OK Cancel

Figure 5.22 Labeling Points

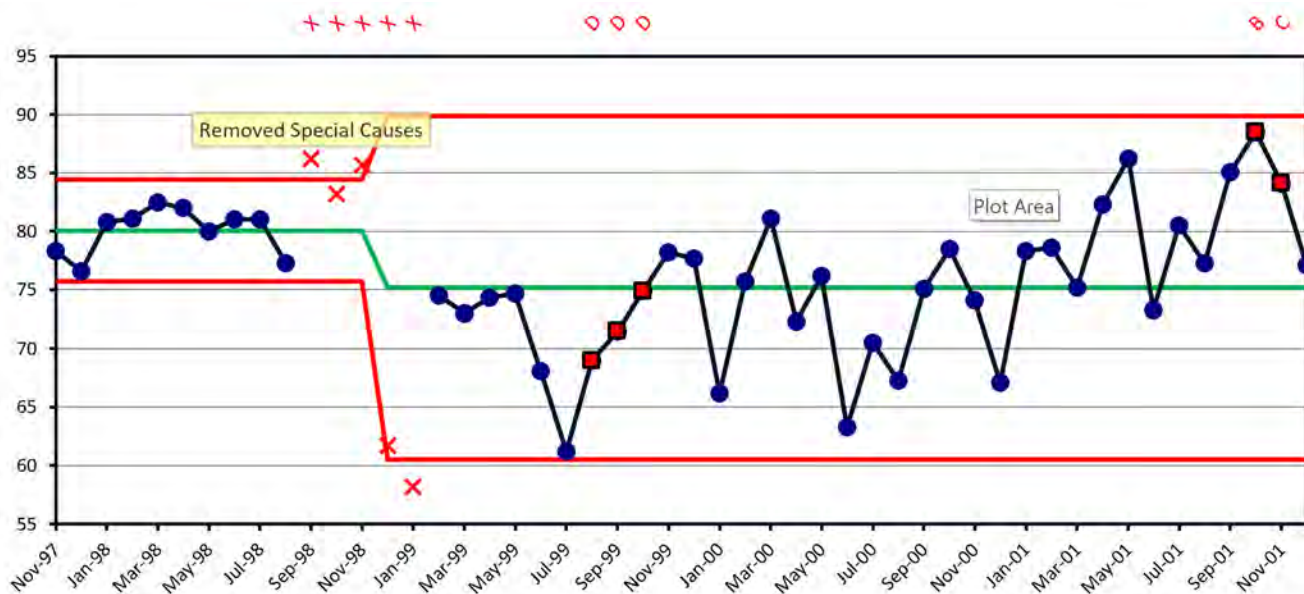


Figure 5.23 Data Point Label

The label can be moved by clicking on it, pressing the “[Cancel](#)” button and then position the cursor over the label click and move it to the desired location.

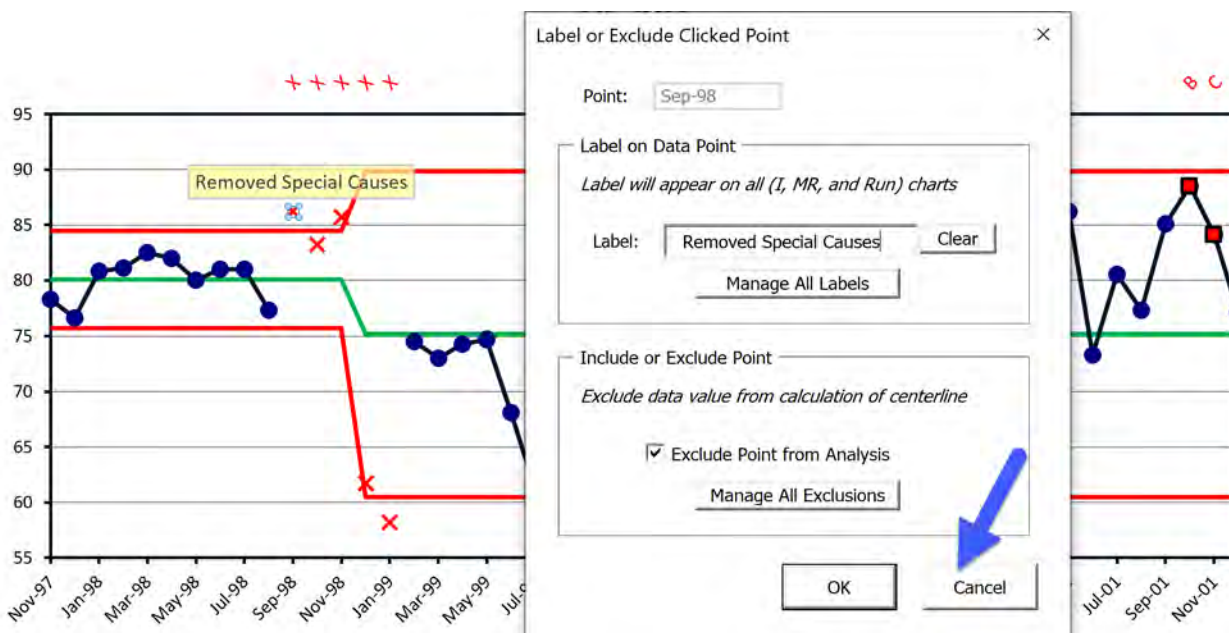


Figure 5.24 Moving a Label

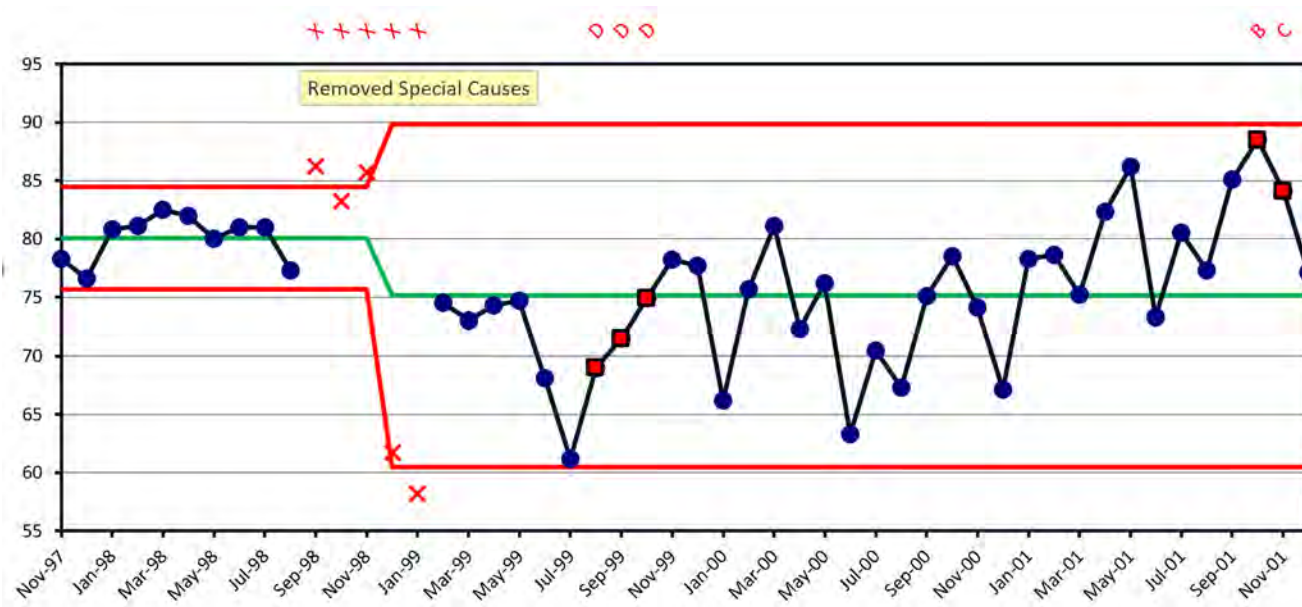


Figure 5.25 Moved Label

MEDIAN MOVING RANGE METHOD TO ESTIMATE LIMITS

Many experts suggest using the Median Moving Range instead of the Average Moving Range because it can remove the effect of large assignable causes patterns on the I Chart.

To use the Median Moving Range method, select the “[Median MR](#)” icon in the “[Analysis](#)” group. This applies only to the active chart.

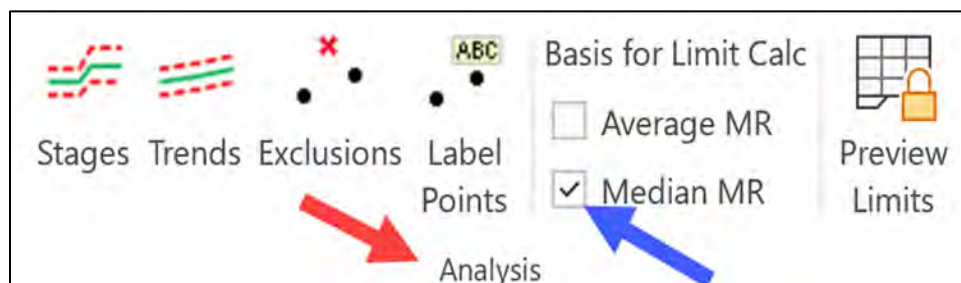


Figure 5.26 Enabling the Median Moving Range

When an I Chart is predictable and contains no Assignable Cause Patterns, the limits of the I Chart are inflated when using the median moving range, see Figure 5.29. The range of the limits are expanded by 27%. I don't recommend using the Median Moving Range when there is no evidence of assignable causes.

What about the case when there is an assignable cause? Typically, an analyst will exclude a large assignable cause.

To exclude points select the “[Exclusions](#)” button in the “[Analysis](#)” group.

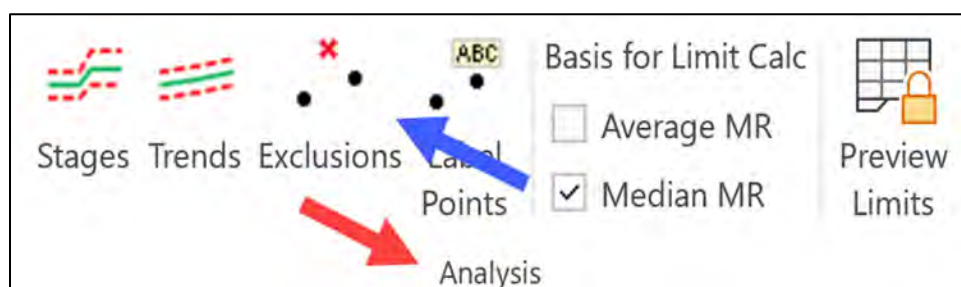


Figure 5.27 Excluding data

In the “[Exclude Points](#)” dialog box, check the “**Small Check Box**” next to the point to be excluded. Exclude July’s value of 20. When done press the “[Apply Changes](#)” button.

Note you can simultaneously exclude points on the “[Moving Range Chart](#)”. There are “[Two Options](#)” for displaying excluded points, showing a “**Red X**” on the Assignable Cause pane above the chart, or just “**Hide Excluded Points**”.

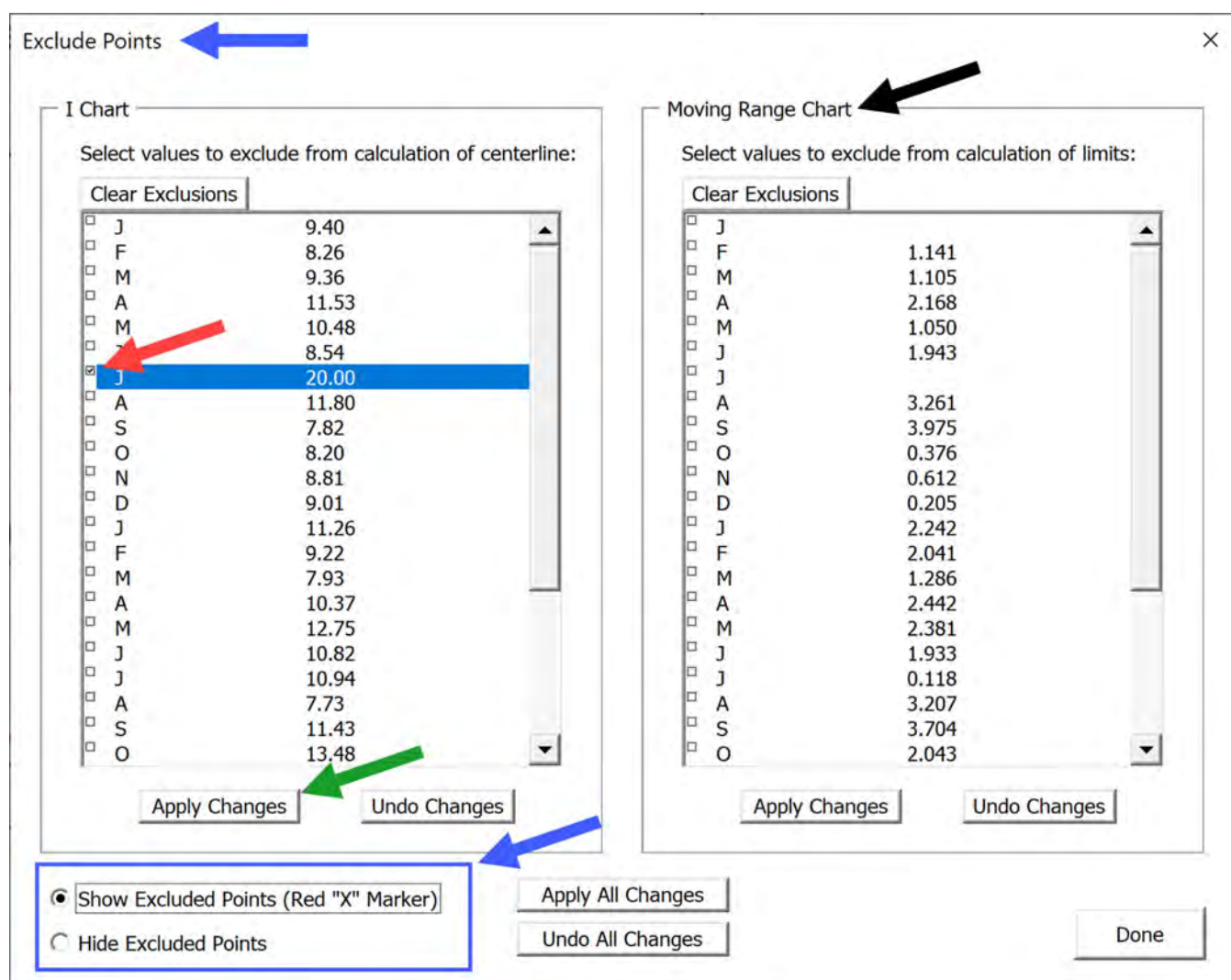


Figure 5.28 Exclude points

Figure 5.30 shows a comparison of removing one large assignable cause pattern using the average moving range vs leaving the assignable cause pattern and using the Median Moving Range. The range of the limits are expanded by 24%.

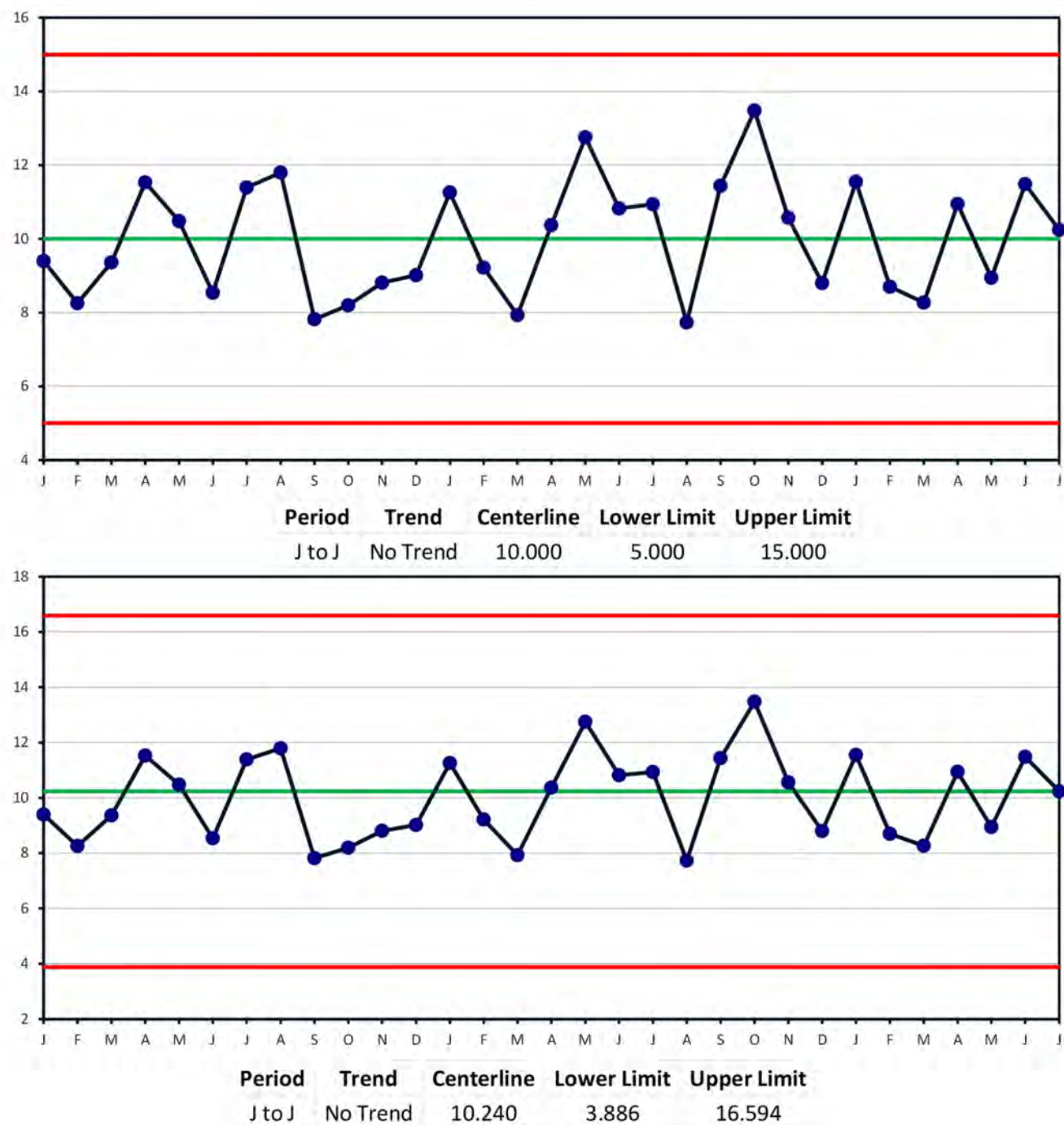


Figure 5.29 Average Moving Range, top Median Moving Range, bottom.

point

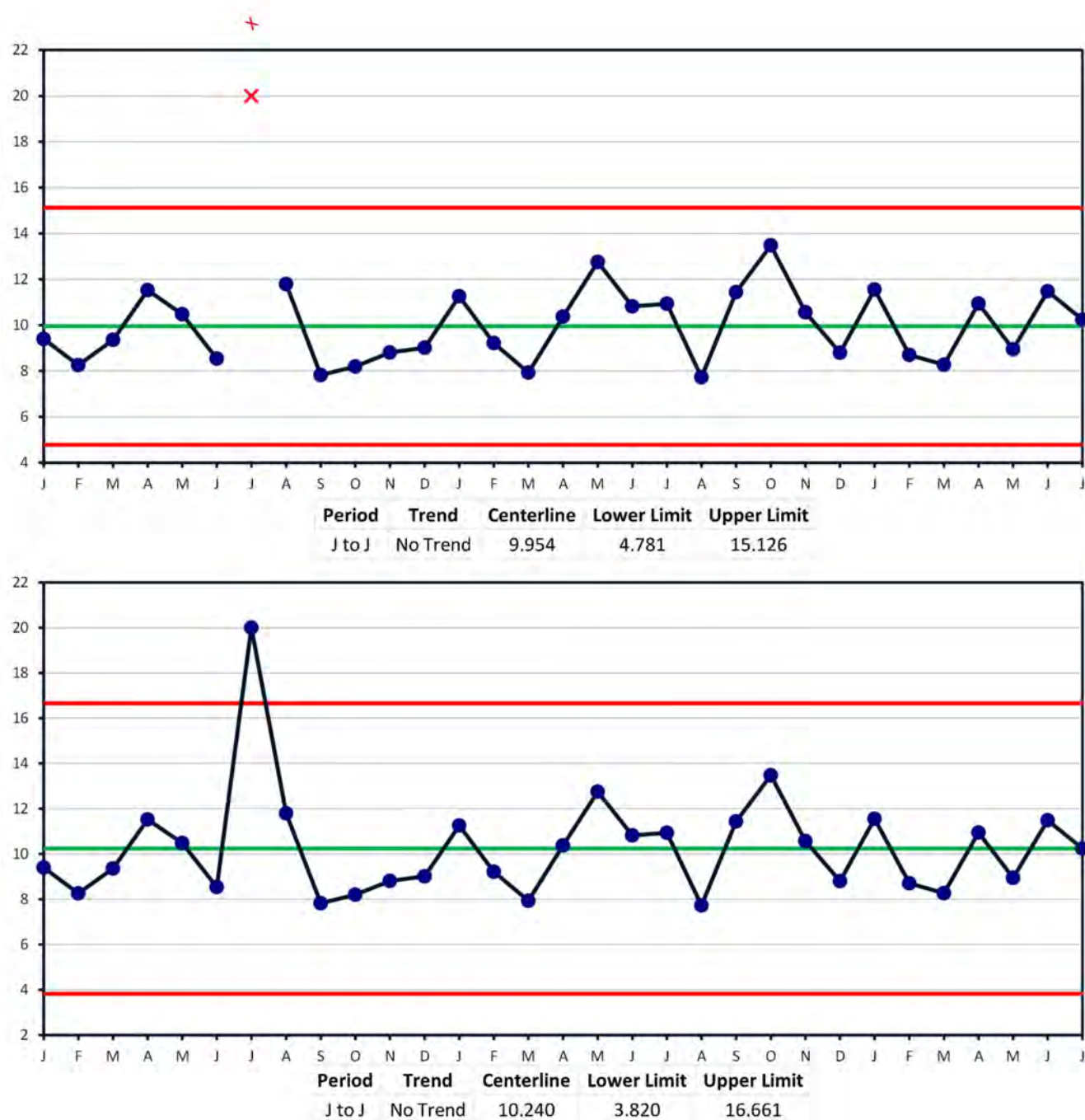


Figure 5.30 Comparison of Excluding a point vs Using Media Moving Range

What about the case when there appears to be multiple assignable cause patterns. In the next example a company builds up inventory every July for their back-to-school sales in September. The last three years inventory is displayed as Figure S3.14

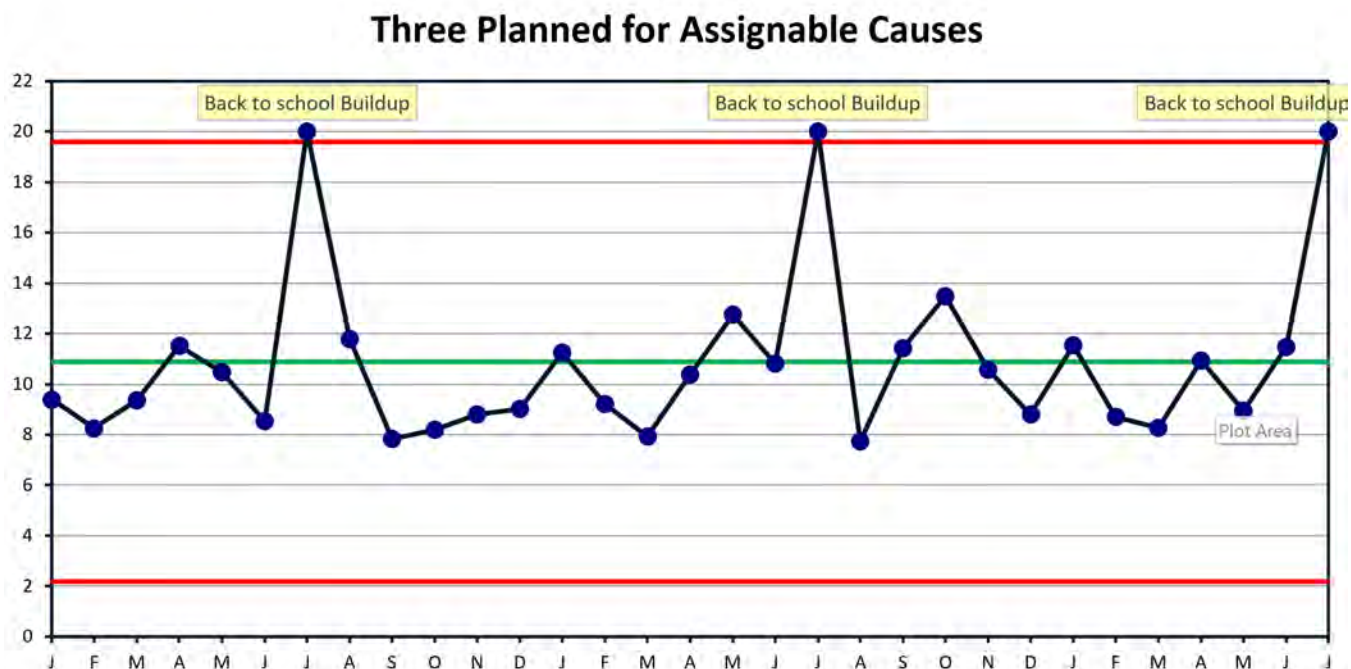


Figure 5.31 Back to School Buildup

The Exclusions vs Median Moving Range comparison for multiple assignable causes is shown in Figure S3.15. The range of the limits are expanded by 28%.

All in all, it seems the use of the median moving range harkens back to the days when it was easier to find the median of a data set than to calculate its average. Today computers do the computations in microseconds so there is little practical value using the Median Moving Range.

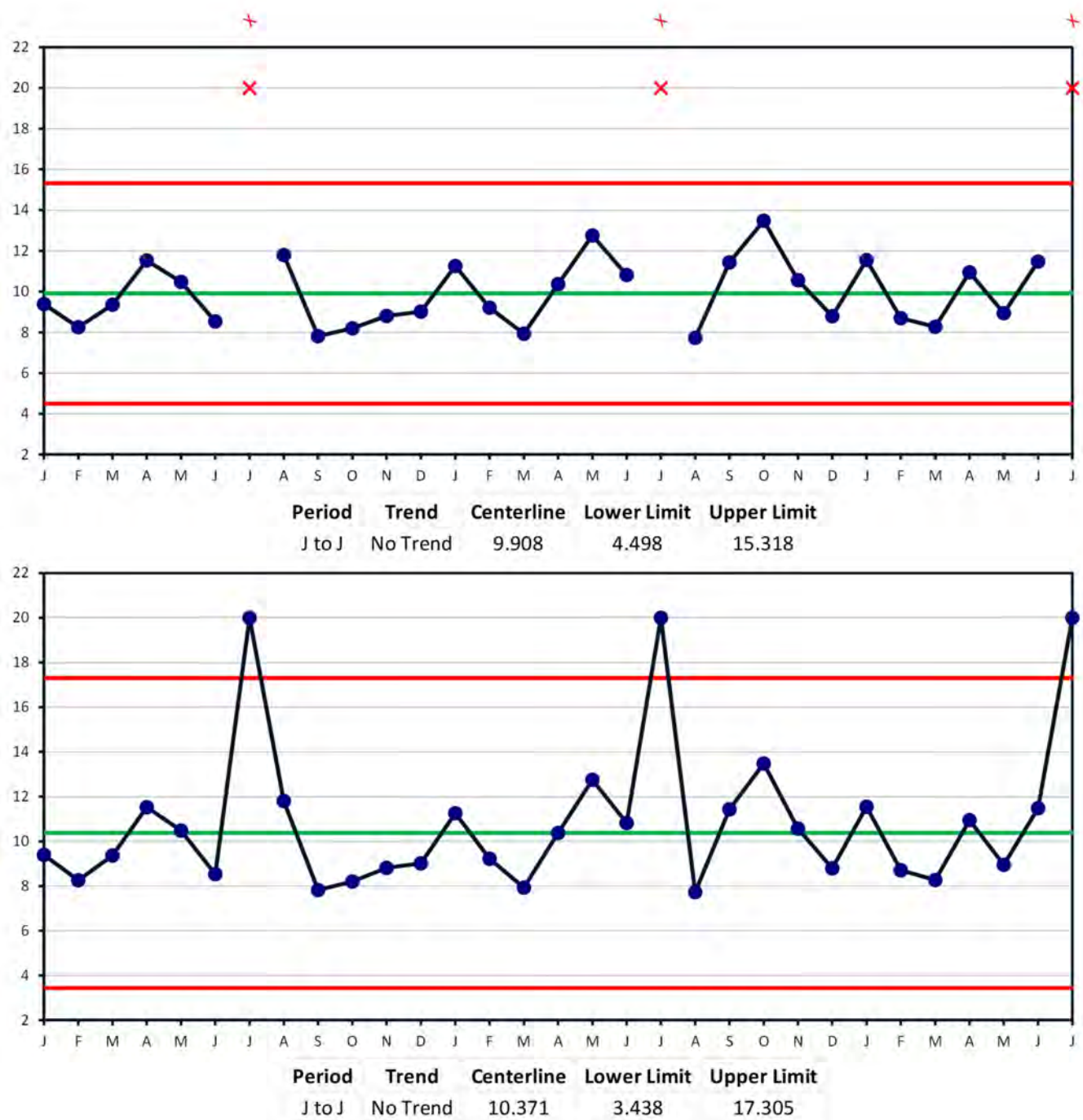


Figure 5.32 Multiple Assignable Causes - Excluding vs Median Moving Range

LOCKING LIMITS

This section will describe how to compute the natural process limits of a selected portion of predictable data.

The purpose of locking limits is to preserve their values when additional data is added to the chart. Another reason is to identify a range of predictable values that defines the “voice of the process”.

Previously I showed how to remove signals in the data due to stages and or trends. In this section I describe another way to identify signals from patterns in the data. These patterns are called Assignable Cause Patterns, and we will describe their use in detail to characterize unpredictable process variation.



Donald Wheeler has given permission to use his data set “In-Process Inventory Values”³

We start by importing data from “[Documents\PBCharts\Understanding Variation Files\Figure 3.3.xlsx](#)”. Press the “Import Data into PBCharts” icon.

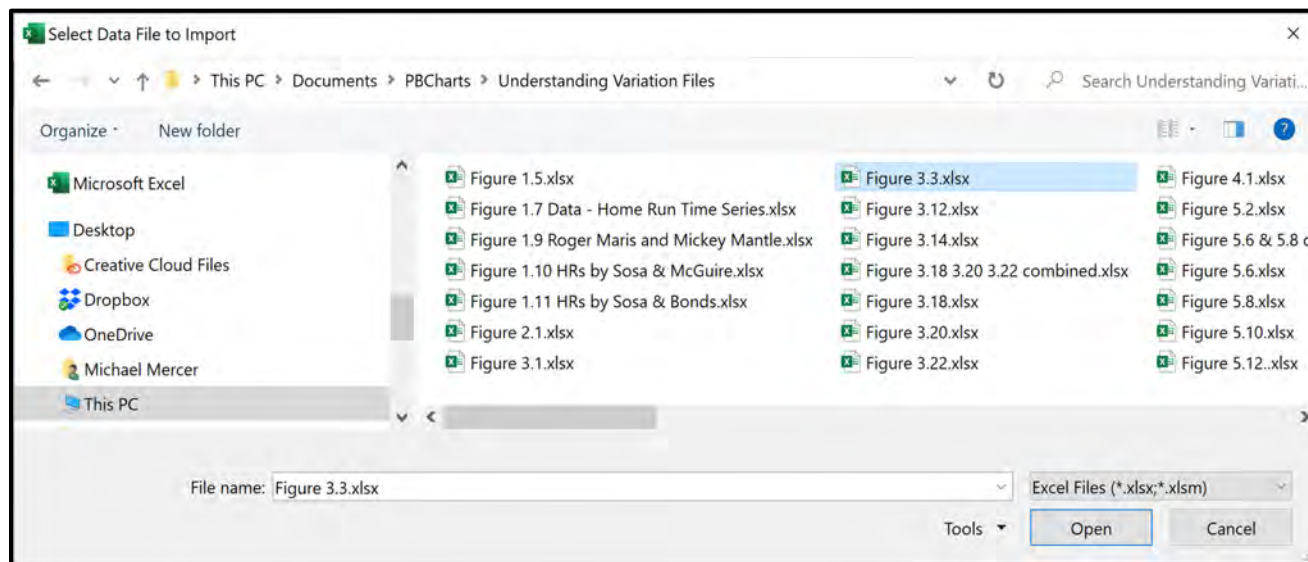


Figure 5.33 Importing Figure 3.3 Data

³ “*Understanding Variation The Key to Managing Chaos*”, page 37, ©2000, SPCPress, Knoxville TN, ISBN 0-945320-53-1

Save the PBCharts version of the file by accepting the default name, “[Figure 3.3.pbct](#)”. Then press “[Save](#)” in the “[Select Folder and Name for New PBCharts File](#)” folder.

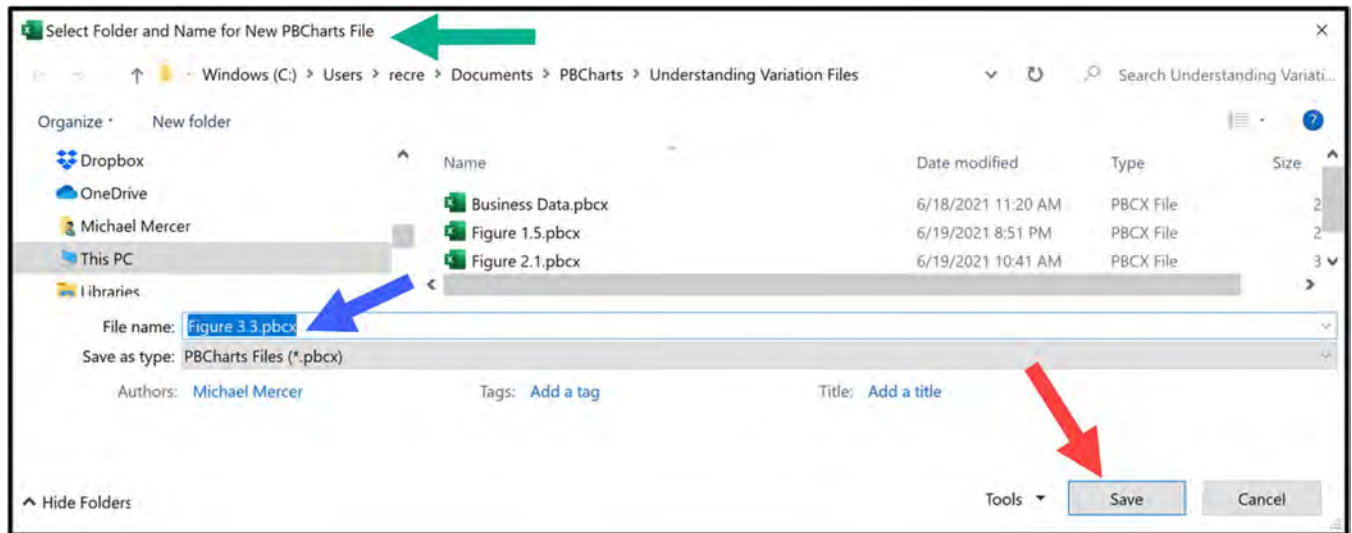


Figure 5.34 Saving In-Process Inventory as a PBCharts file

Press the “I Chart” worksheet tab to view the

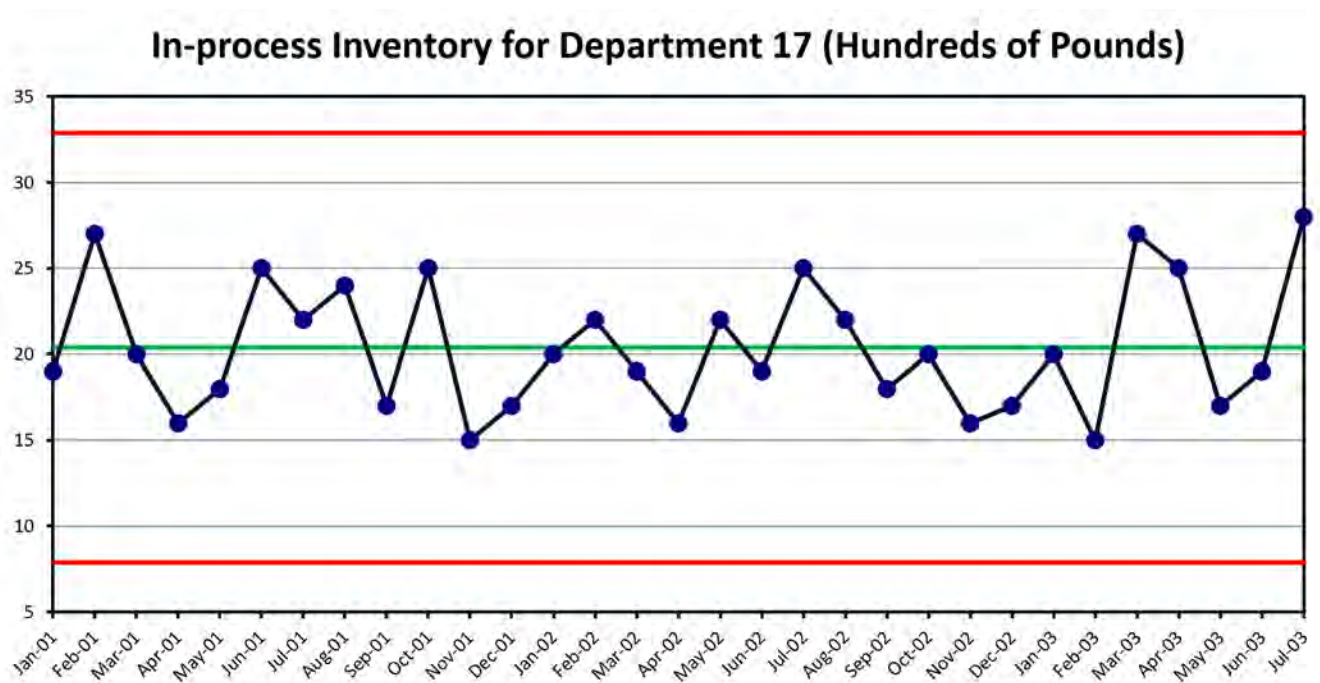
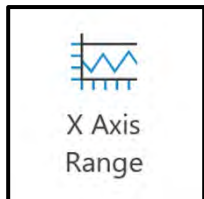


Figure 5.35 Process Behavior Chart for In-Process Inventory

The file contains almost three years of In-Process Inventory data and Wheeler chose to use the first two years to set his base period.



Use the “X Axis Range” icon to select the first 24 data points.

In the “[Select X Axis Display Range](#)” dialog box, select “[Dec-02](#)” for the “[Ending Point](#)” to restrict the visible range to two years of data from “Jan-01” (January the first year) to “Dec-02” (December the second year).

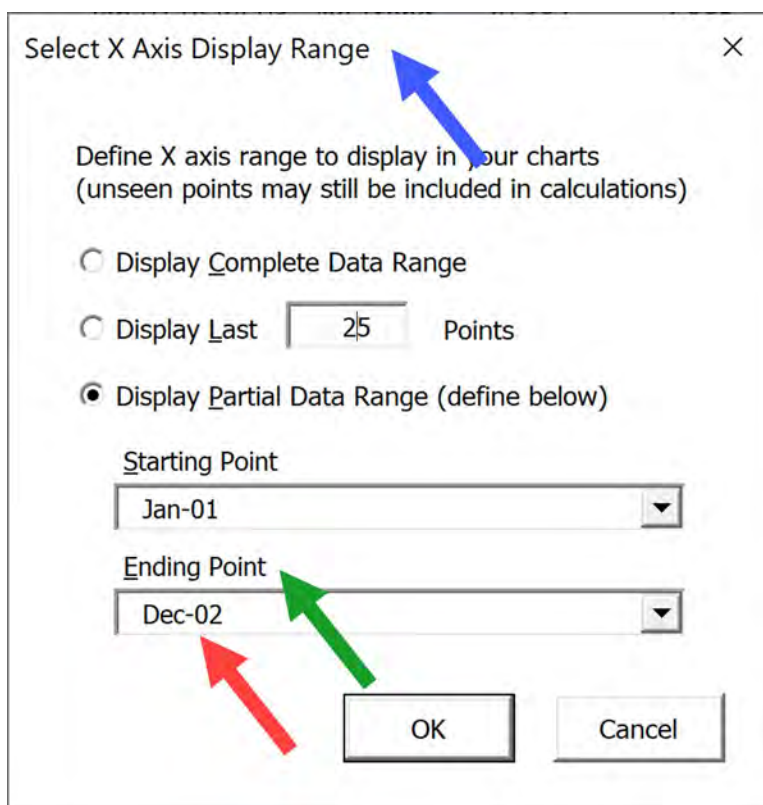
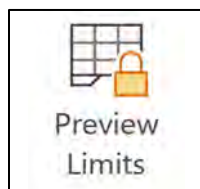


Figure 5.36 Selecting the first two years data to set the base period.



Press the “Preview Limits” icon and the limits change to give a preview of the data based on just the visible data. If the data shows only routine variation, then we can accept the limits as representing a predictable process. If the data shows unpredictable variation, we can choose a different range of data or if there are only a few outliers we can exclude them.

The “**Preview Lock Limits**” dialog opened and allows two choices. Keep the “**Extend Limits backward to all historic data**” selection, the other option will be discussed further on.

Press the “**Lock Limits**” button to accept the data as representing a predictable process, we will explore later using the assignable cause pattern tests to confirm predictability.

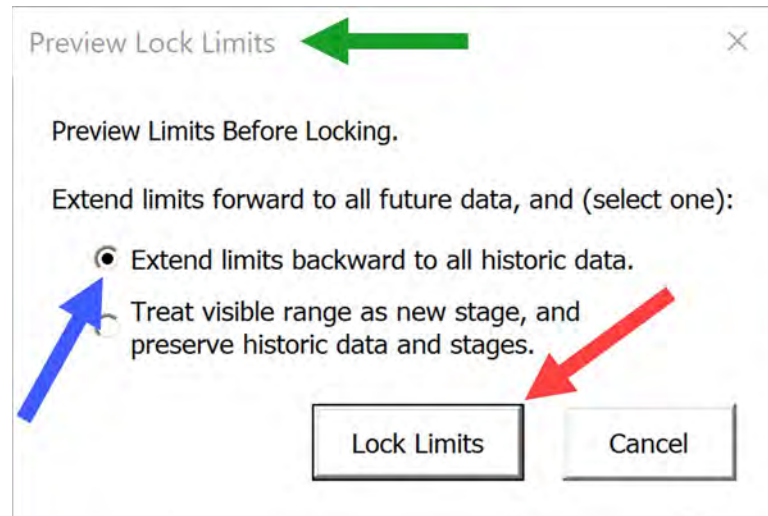


Figure 5.37 Locking Limits

The PB Chart appears to be predictable process as there are no assignable cause patterns showing.

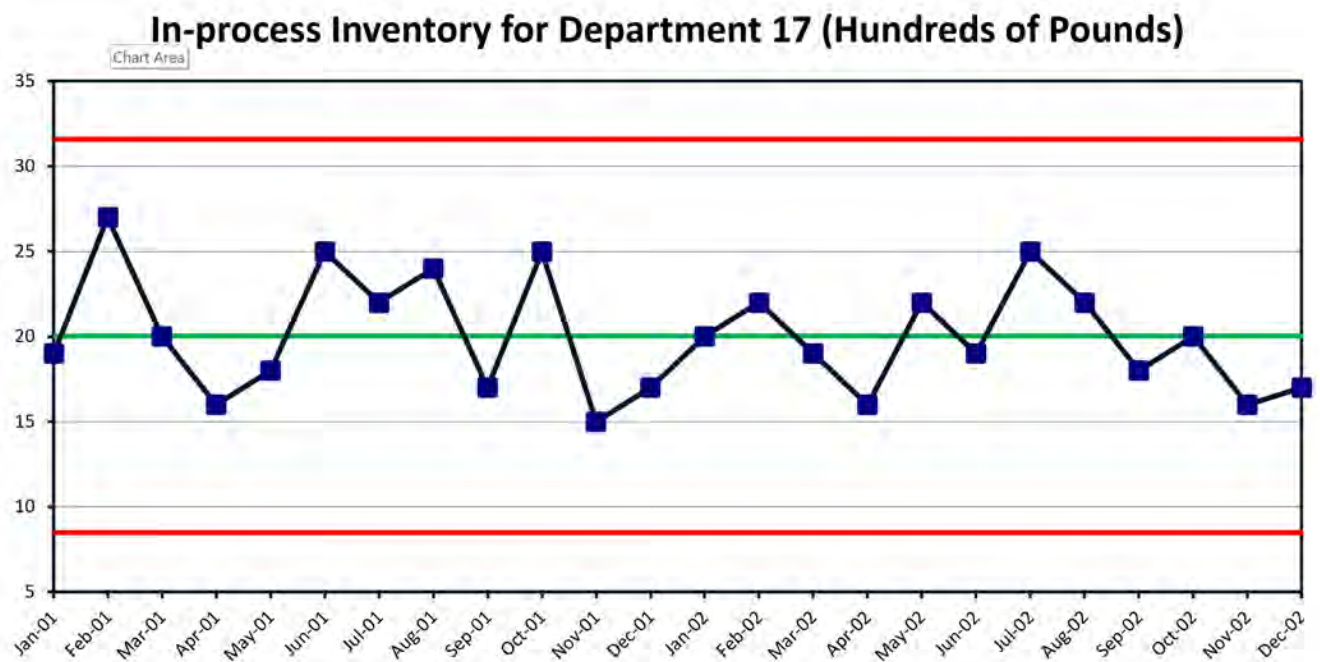


Figure 5.38 PB Chart of In-Process Inventory for the first two years

Notice that the data points used to calculate the limits are now displayed as squares instead of round points. Press the “**MR Chart**” worksheet tab to see the Moving Range which also appears predictable.

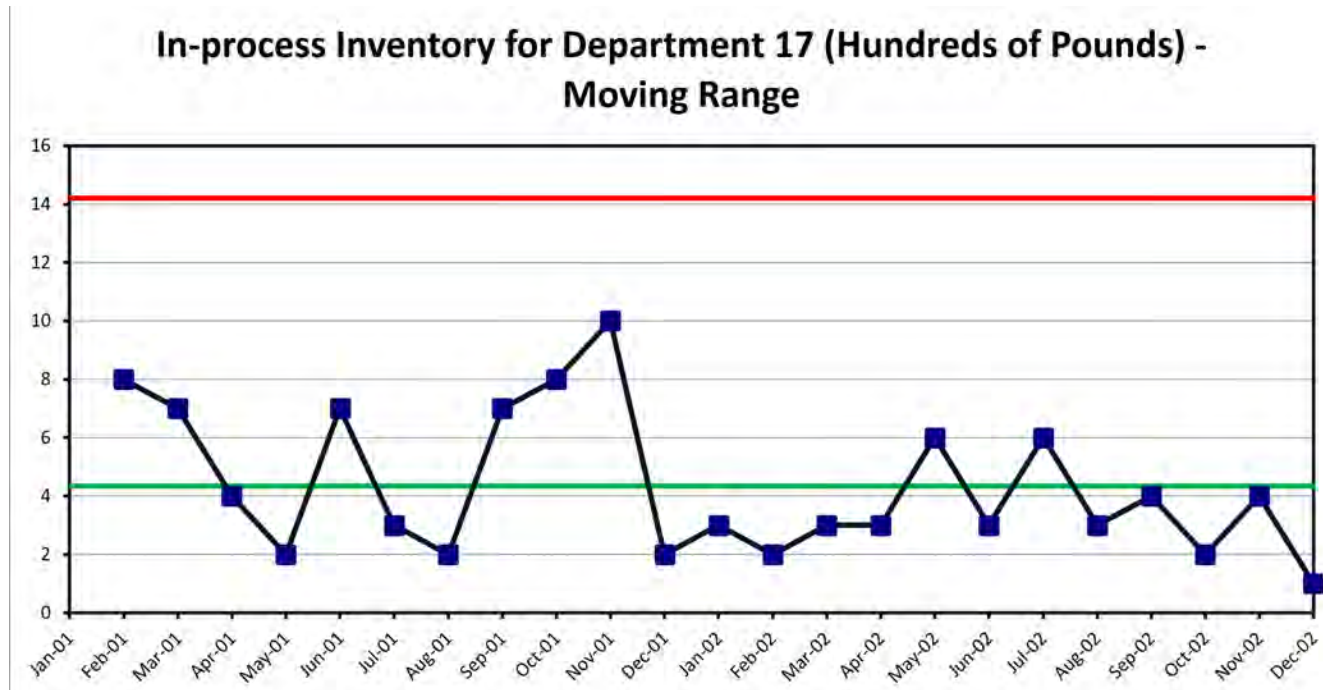
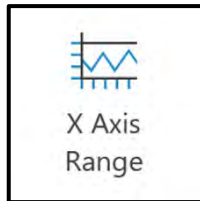


Figure 5.39 MR Chart of In-Process Inventory for the First Two Years



Select the “X Axis Range” icon and reset the X Axis range to show all the data. Select the “[Display Complete Data Range](#)”

Select X Axis Display Range

Define X axis range to display in your charts
(unseen points may still be included in calculations)

☒ Display Complete Data Range

☐ Display Last 25 Points

☐ Display Partial Data Range (define below)

Starting Point
Jan-01

Ending Point
Dec-02

OK Cancel

Figure 5.40 Selecting the Complete Data Range

The subsequent I Chart, and the MR Chart, match Figure 3.10 in the book. Notice the square points represent the data used to calculate the limits.

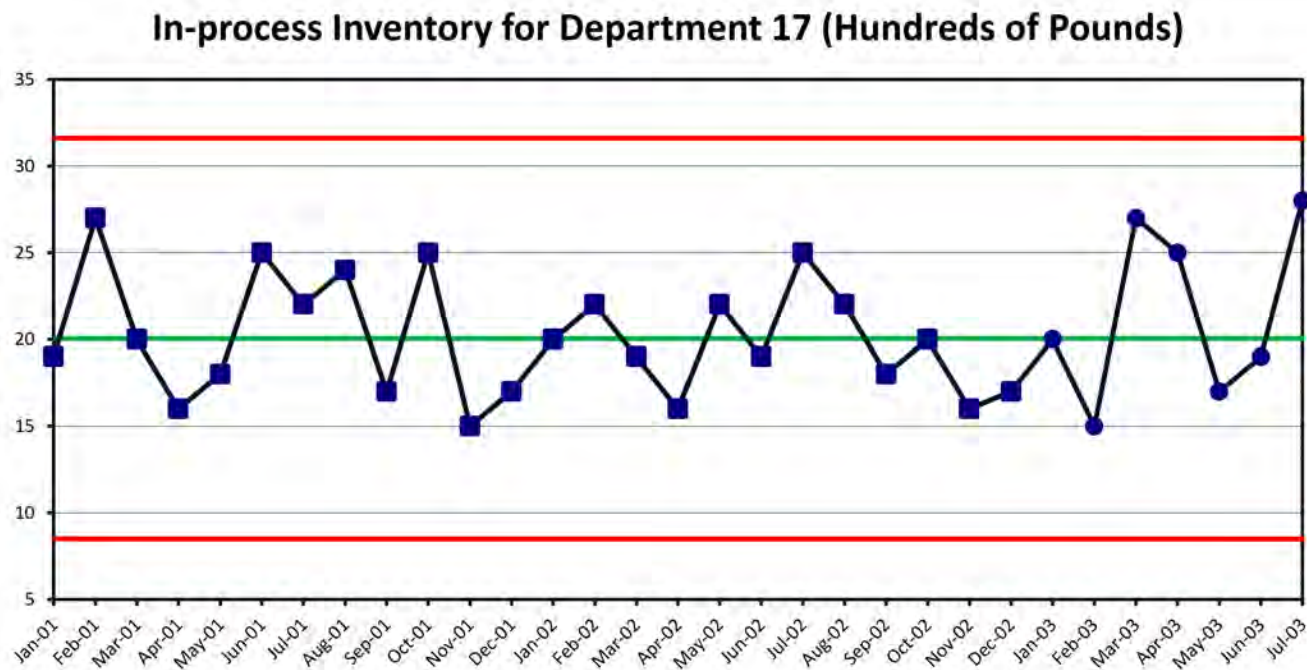


Figure 5.41 PB Chart of In-Process Inventory

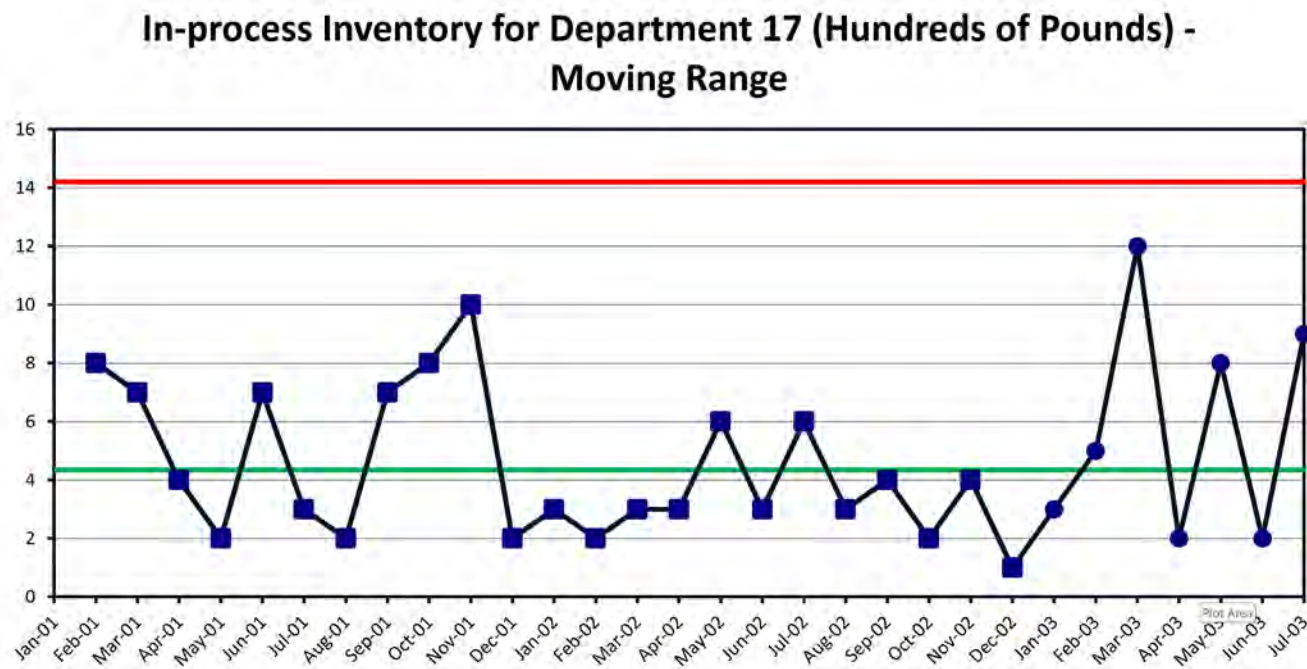


Figure 5.42 MR Chart of In-Process Inventory

The second option in the “**Preview Lock Limits**” dialog box, is “**Treat visible range as a new stage, and preserve historic data and stages**”.

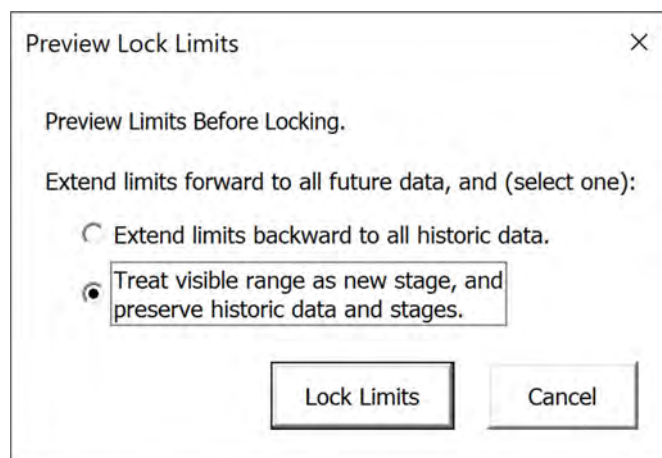


Figure 5.43 Using the second option for Locking Limits

This option will calculate and display limits for any data preceding the visible range. As an example, if the second year was used to set limits, and we locked limits using the second option and used the X Axis Range icon to look at all the data, the I Chart would now look like Figure 5.44 below. Note square points depict the data range used to calculate the limits.

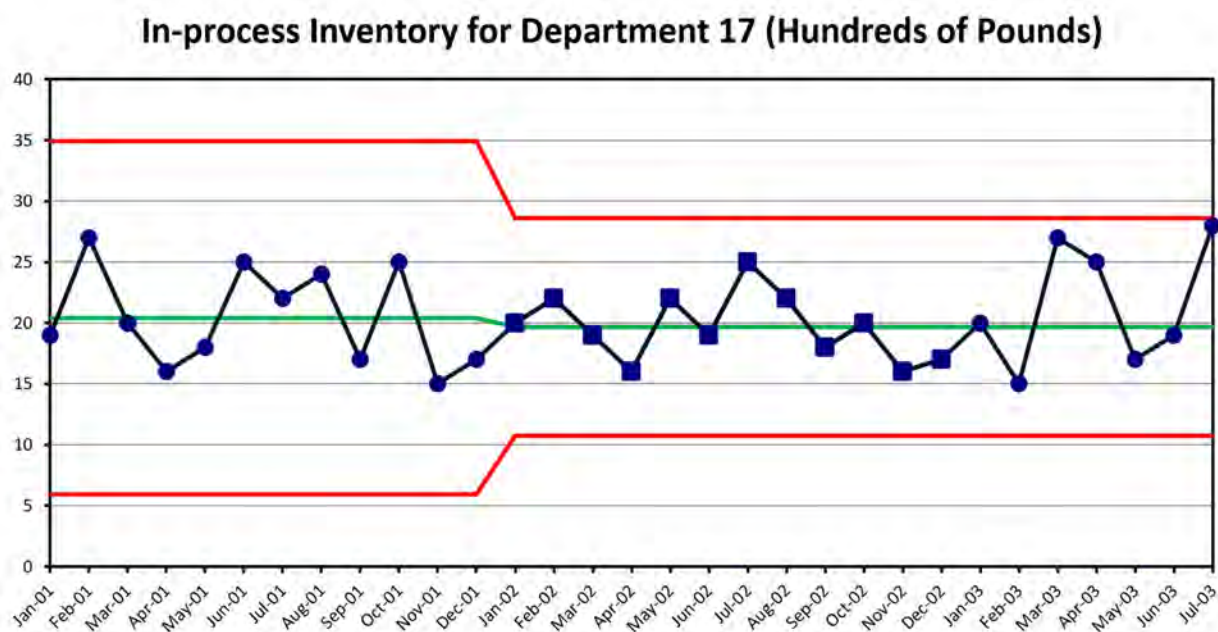


Figure 5.44 In-Process inventory, Limits based on year two.

It appears there is less variability in year two than in year one, and the Moving Range Chart affirms this.

In-process Inventory for Department 17 (Hundreds of Pounds) - Moving Range

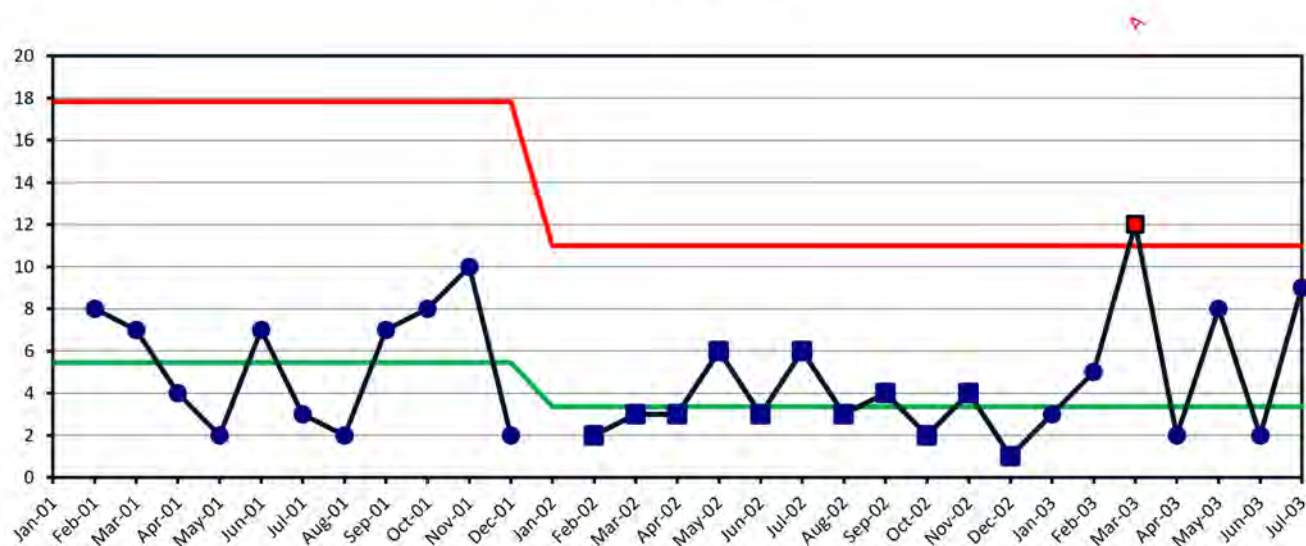


Figure 5.45 Moving Range, Limits based on year two

The limits based only on Year Two seems to fit the I Chart well enough, but the Moving Range has an assignable cause pattern code, so it appears that the better choice of a data range to set limits is both year one and Year two.

Statistically speaking, the limits are better precisely estimated as more data is used.

AIRLINE DATA - THE REST OF THE STORY

More time has elapsed and the Airline On Time I Chart is full of Assignable Cause Patterns.

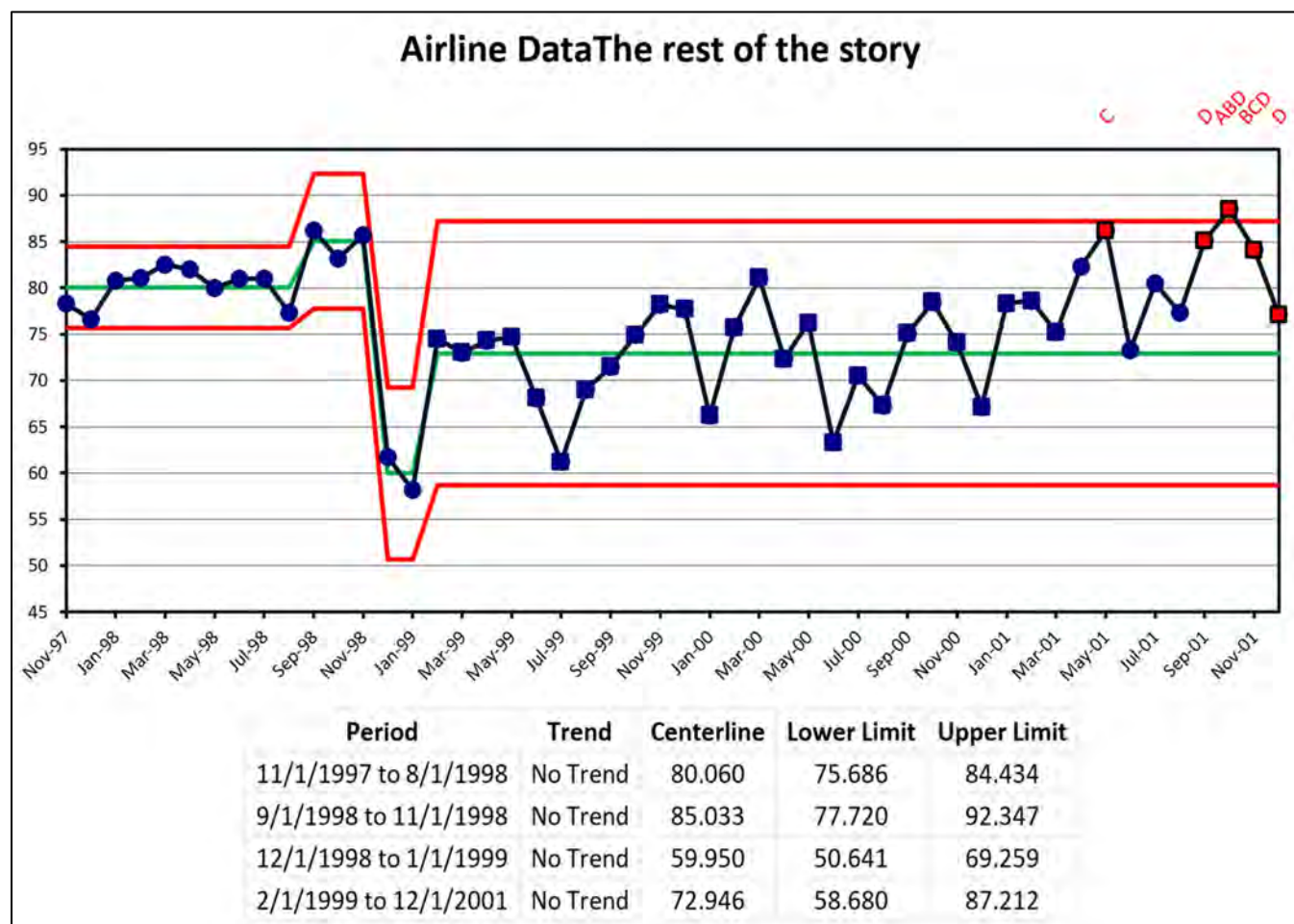


Figure 5.46 Locked Limits for Airline Data

The natural process limits for the fourth stage are the same as shown in Figure 5.9 On-Time Airline data with four stages and they are preserved as the new data was entered.

It looks like the airline has made some improvement. Assignable Cause Pattern Code C, **“Small shift, 4 of 5 points same side of centerline”** appears in **“May-01”**. Counting back 5 points from **“May-01”** seems to suggest **“Jan-01”** as the starting point for the shift.

To model this shift I will have to unlock the current limits, select the dates **“Jan-01”** through **“Dec-01”** and lock these limits selecting the **“Treat visible range as a new stage, and preserve historic data and stages”** in the Lock limits dialog box..

Figure 5.47 tells the whole story.

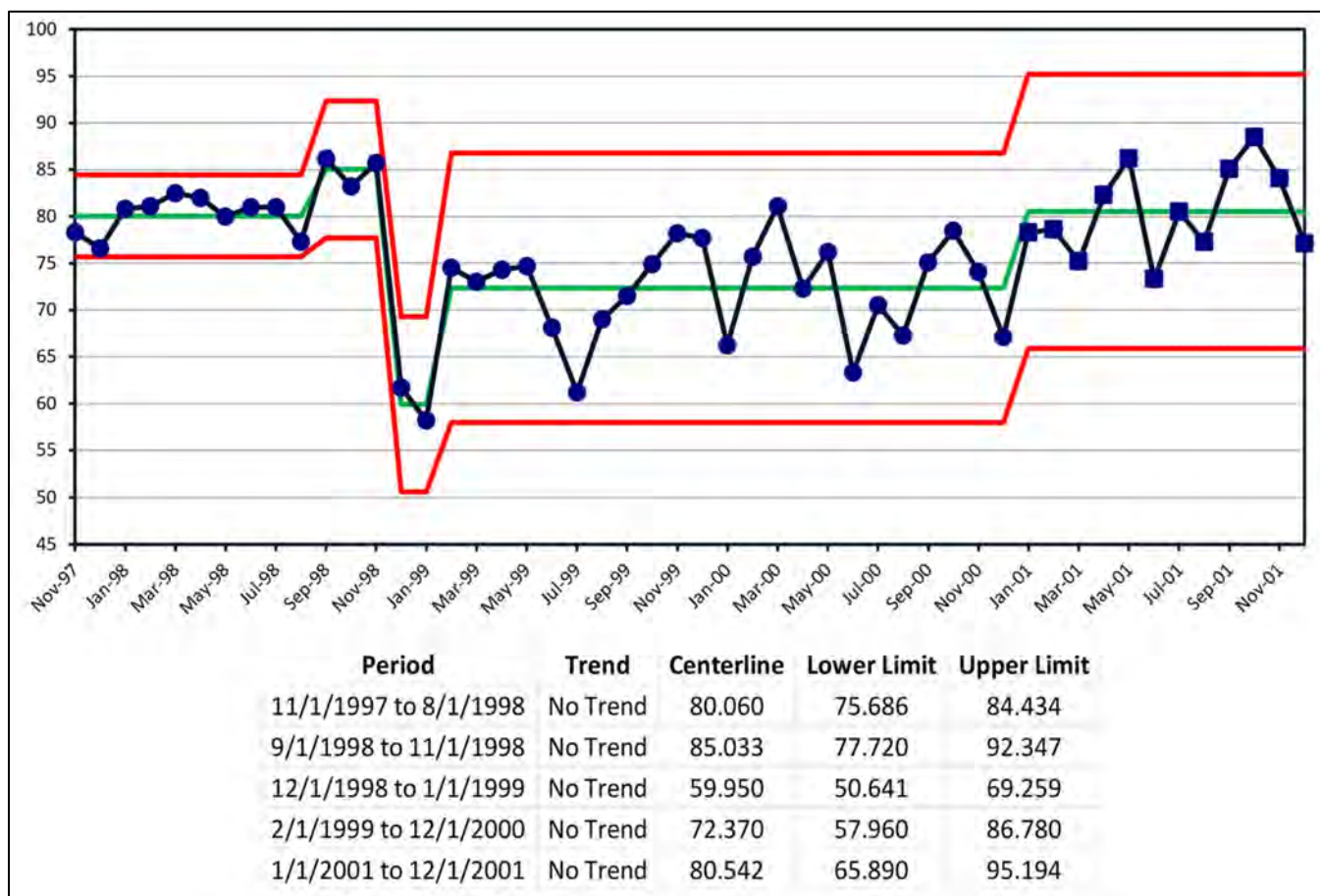


Figure 5.47 The Whole story

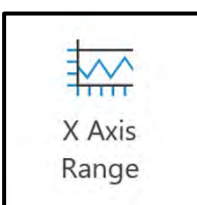
A fifth stage, from “Jan-01” to “Dec-01” was added and the limits are locked to allow comparison to future data.

The natural process limits for the fourth stage are changed because the data range is different than before.

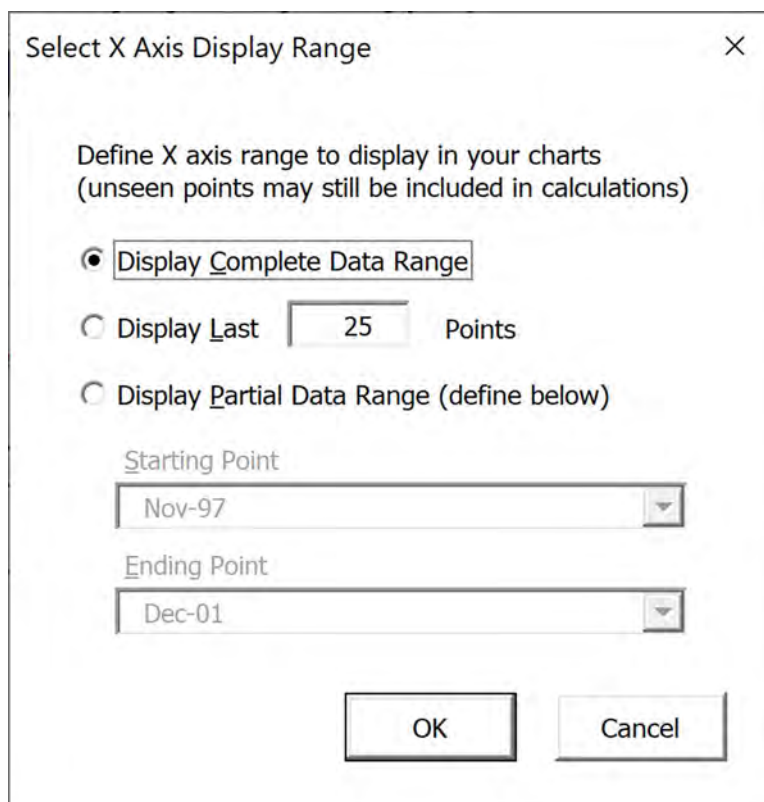
Chapter 6

CHARTS GROUP

X AXIS RANGE



The “**X axis**” icon contains three ways to select how the x axis data is to be displayed.

The dialog box is titled "Select X Axis Display Range" with a close button (X) in the top right corner. The main text reads: "Define X axis range to display in your charts (unseen points may still be included in calculations)". There are three radio button options: "Display Complete Data Range" (selected), "Display Last 25 Points", and "Display Partial Data Range (define below)". Below the third option, there are two dropdown menus: "Starting Point" with "Nov-97" selected, and "Ending Point" with "Dec-01" selected. At the bottom are "OK" and "Cancel" buttons.

Select X Axis Display Range

Define X axis range to display in your charts
(unseen points may still be included in calculations)

☒ Display Complete Data Range

☐ Display Last 25 Points

☐ Display Partial Data Range (define below)

Starting Point
Nov-97

Ending Point
Dec-01

OK Cancel

Figure 6.1 Selection of X axis display options.

The first option shows all the data which is useful when you perform a diagnostic evaluation of the past performance of the process. Using stages and trends can help clarify past performance.

The second option is most useful when using PBCharts as a monitoring and measurement tool. Typically, the time frame for business data is months. Choosing the last 25 months allows display of this year's this month data, last year's this month data and two years ago this month's data. For instance, the chart below shows the data for Dec-99, Dec-00, and Dec-01.

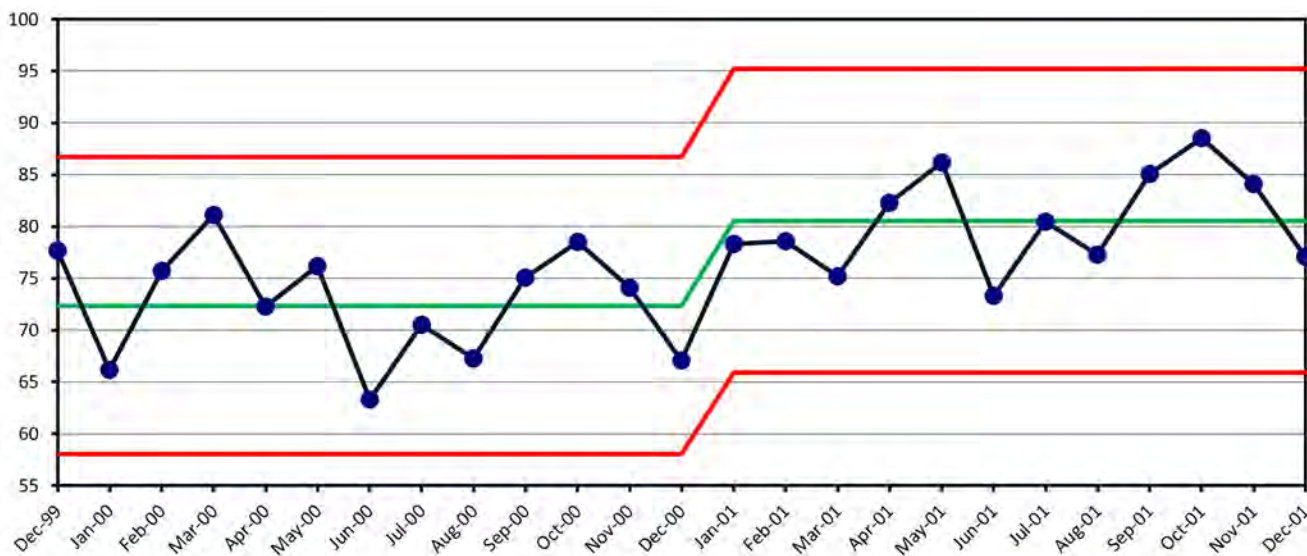


Figure 6.2 Last 25 data points

If the data were in quarters, you could change the default number to 9 to see the same last two years plus a quarter from three years ago, i.e. Q1 - 19, Q1 - 20 and Q1 - 21.

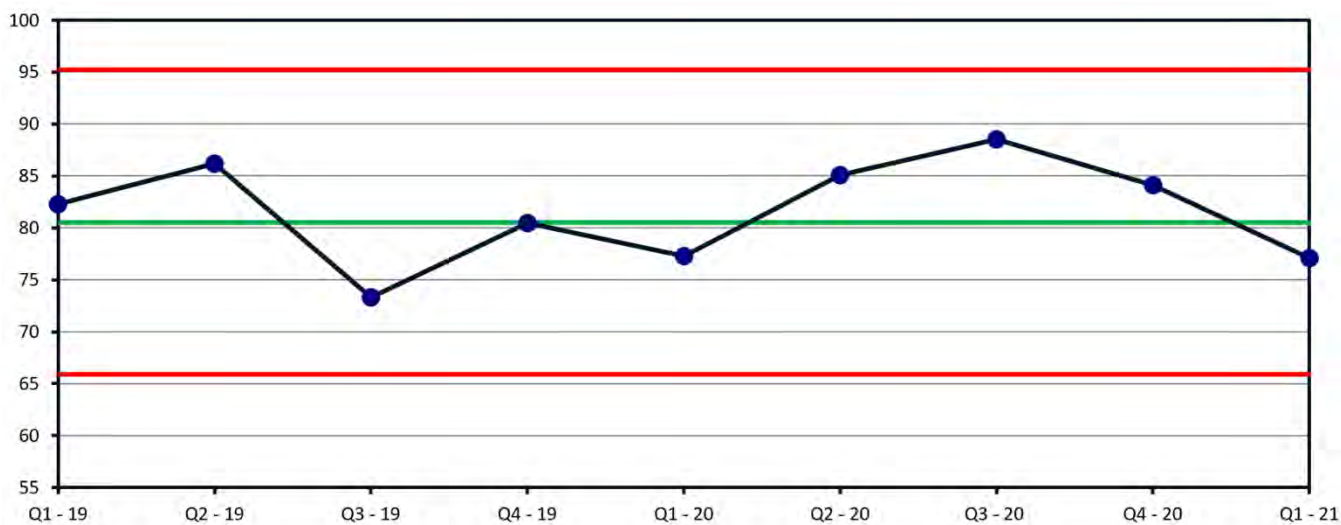
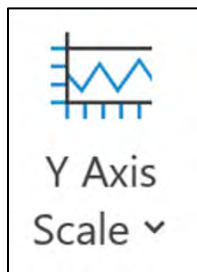


Figure 6.3 - Data by Quarters

The last choice allows selection of a specific range of data to be displayed. It is most useful when freezing the natural process limits of a set of predictable data.

Y AXIS SCALE



The “**Y Axis Scale**” icon allows the user to select the Y axis range in three different ways.

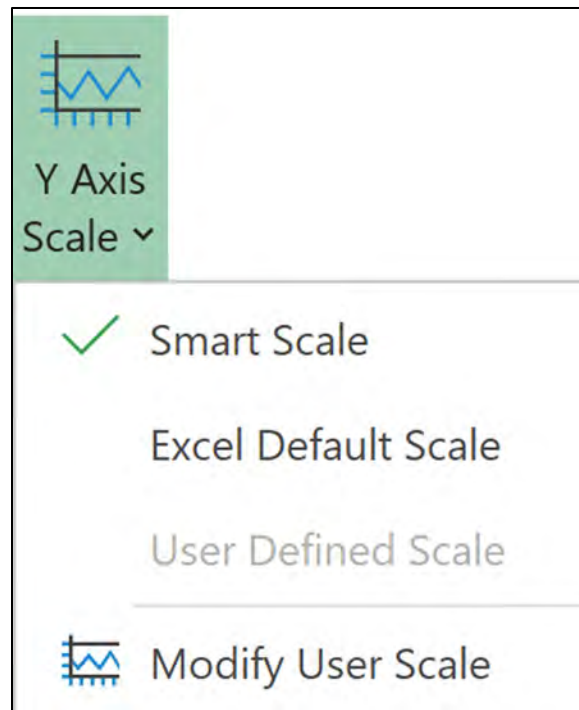


Figure 6.4 Y Axis Scale

The “**Smart Scale**” is PBCharts default and maximizes the area between the upper and lower natural process limits, it is what you have seen already.

The “**Excel Default Scale**” generally includes zero on the Y axis, and generally shrinks the area between the natural process limits.

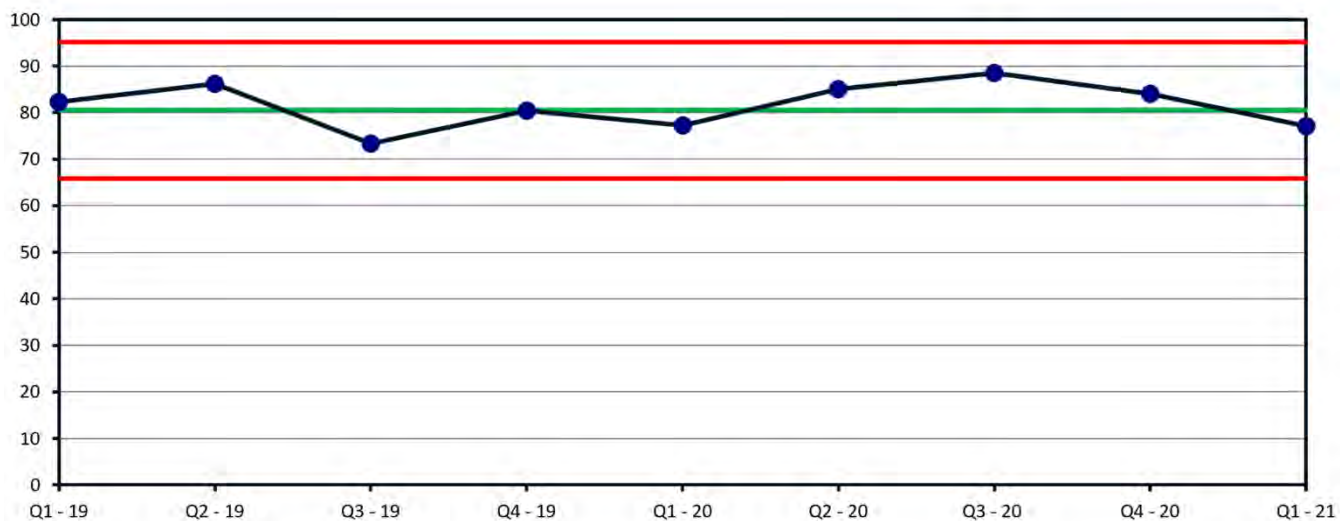


Figure 6.5 - Excel Default Y Axis Scale Contains Zero

The “**Modify User Scale**” can be used to great advantage when you want several charts to have the same Y Axis range of values. In that case check the “[Apply this scale to all of your charts](#)”.

User-Defined Scale

×

Enter any or all axis scale parameters for your I charts.

Excel axis scale defaults will be used for items left blank.

	Data	User-Defined
Minimum	58.018236	50
Maximum	95.195848	100
Major Unit		

Clear All

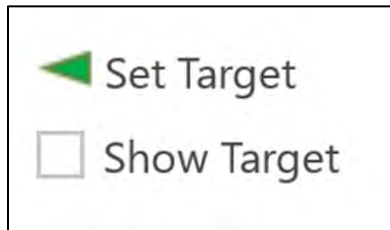
☒ Apply this scale to all of your charts.

OK

Cancel

Figure 6.6 - Applying Y Axis Scale to All Charts

SET AND SHOW TARGETS



You can add a green arrow to any chart by clicking the “**Set Target**” icon and the “Target ” dialog box opens where you can enter the target value.

 A dialog box titled 'Target' with a close button (X) in the top right corner. Inside the dialog, there is a text prompt 'Enter a target value for this I chart.' followed by a text input field. Below this, there is a checkbox labeled 'Apply this target value to all I charts.' At the bottom of the dialog are two buttons: 'OK' and 'Cancel'.

Figure 6.7 - Target Dialog

You can enter individual targets for each chart or select the same target for all charts by checking the “Apply this target to all I Charts. using the

Once you select a target the “**Show Target**” icon becomes checked. To hide a target uncheck the “**Show Target**” icons check box.

A target of 85 was set for the following Figure 6.8.

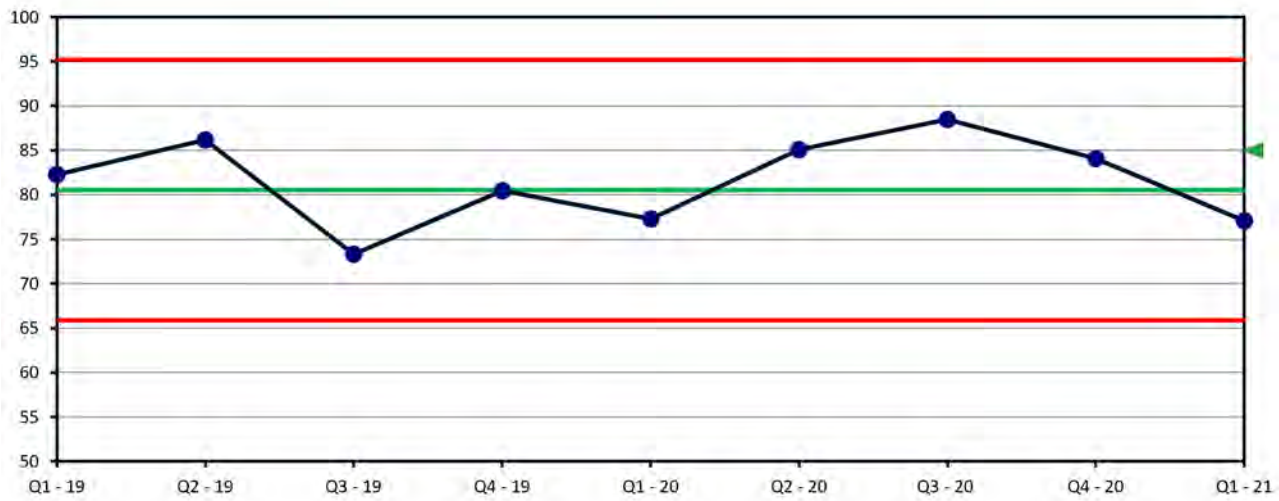


Figure 6.8 - Target on I Chart

RUNS TESTS

The previous chapter discussed setting limits for I Charts and MR Charts. One Special Cause Pattern, a large shift, with a point outside the limit was discussed, primarily with the intent of how to set limits when they appeared.

This section will explore several assignable cause patterns. The presence of assignable cause patterns is an indication the data is not random. Two methods to assess non-randomness will be discussed, examination of runs tests on the run chart, and identification of assignable cause patterns on the I Chart and MR Chart.

Assignable cause patterns will be reviewed in detail.

TESTS FOR RANDOMNESS ON THE RUN CHART

The first runs test is the Runs about Median test.

The NIST/Semitech Statistical Handbook⁴ section 1.3.5.13. Runs Test for Detecting Non-randomness defines a run in the following manner.

Code values above the median as positive and values below the median as negative. A run is defined as a series of consecutive positive (or negative) values.

The runs test can be used to answer the following question? Was the data generated from a random process? Randomness is one of the key assumptions in determining if a process is predictable.

Runs tests can only be displayed on a Run Chart. To start a run test, click on the “[No Run Test](#)” icon and click either on “[Runs About Median](#)” or “[Runs Up or Down](#)”.

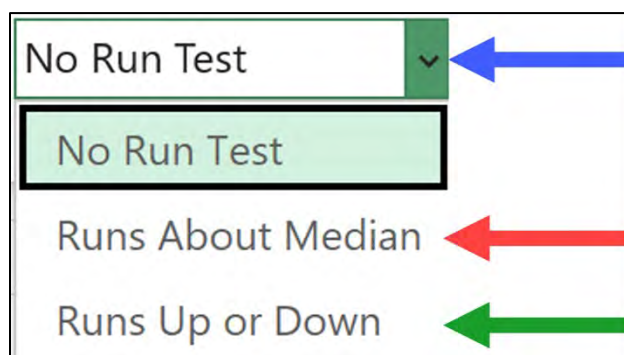


Figure 6.9 Runs Test

⁴ <https://www.itl.nist.gov/div898/handbook/>

The runs test “**Runs About Median**” calculates the expected number of runs about the median, the number of runs that you would expect to have in your data if the data are randomly distributed. More runs than expected may indicate that data are a Mixture from different populations that are mixed alternately into one data stream.

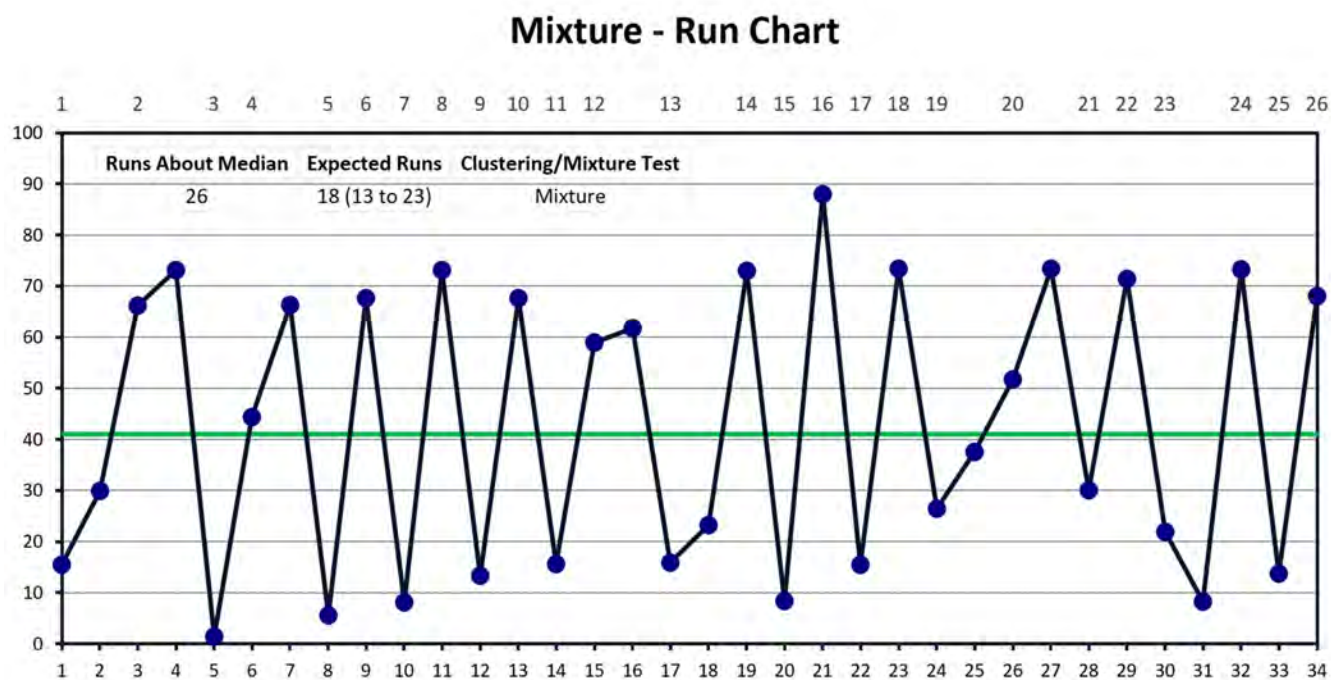


Figure 6.10 Mixture Pattern

Fewer runs than expected may indicate a clustering or different stages of data.

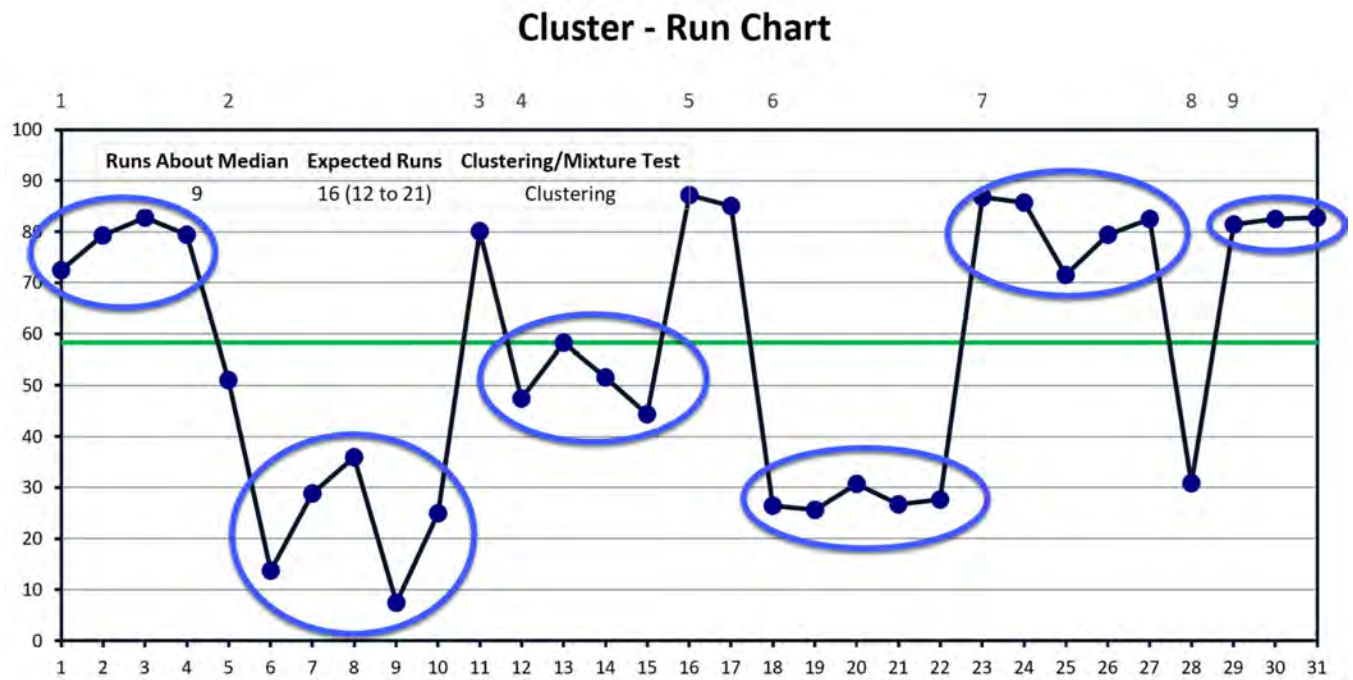


Figure 6.11 Cluster Patterns

The runs test “**Runs up or Down**” calculates the expected number of runs up or down that you would expect to have in your data if the data are randomly distributed.

More runs than expected may indicate oscillation in the data. Oscillation is where every point alternate between up and down.

Oscillation - Run Chart

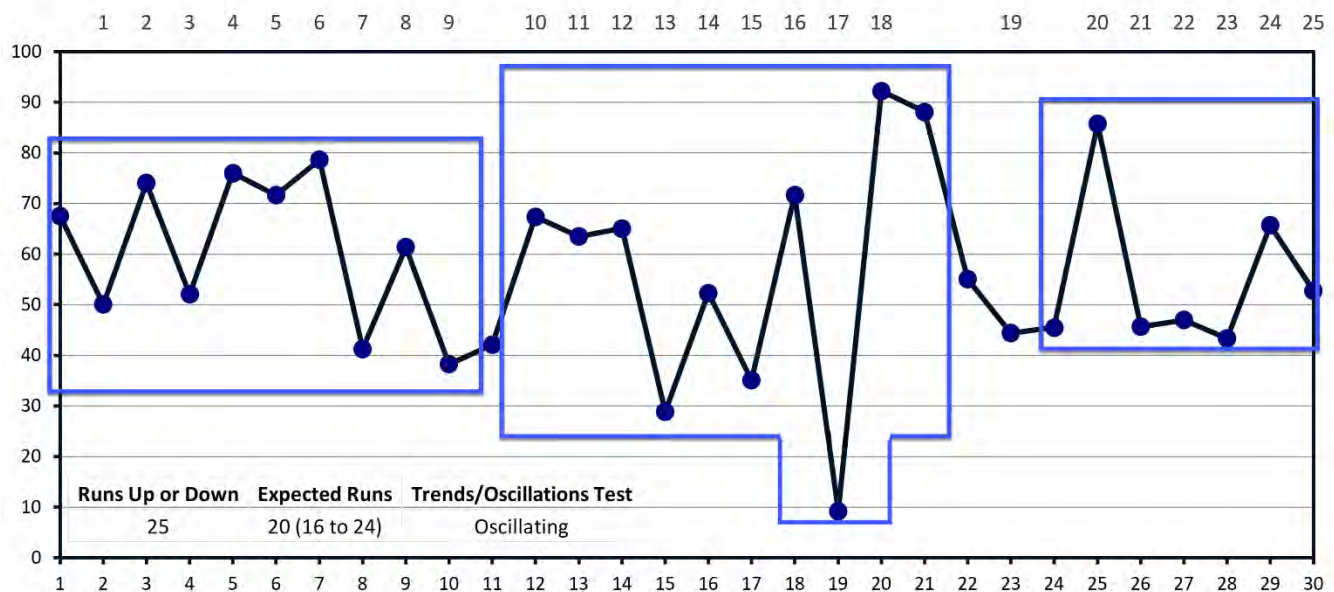


Figure 6.12 Oscillation Pattern

Fewer runs than expected may indicate a trend in the data.

Trend - Run Chart

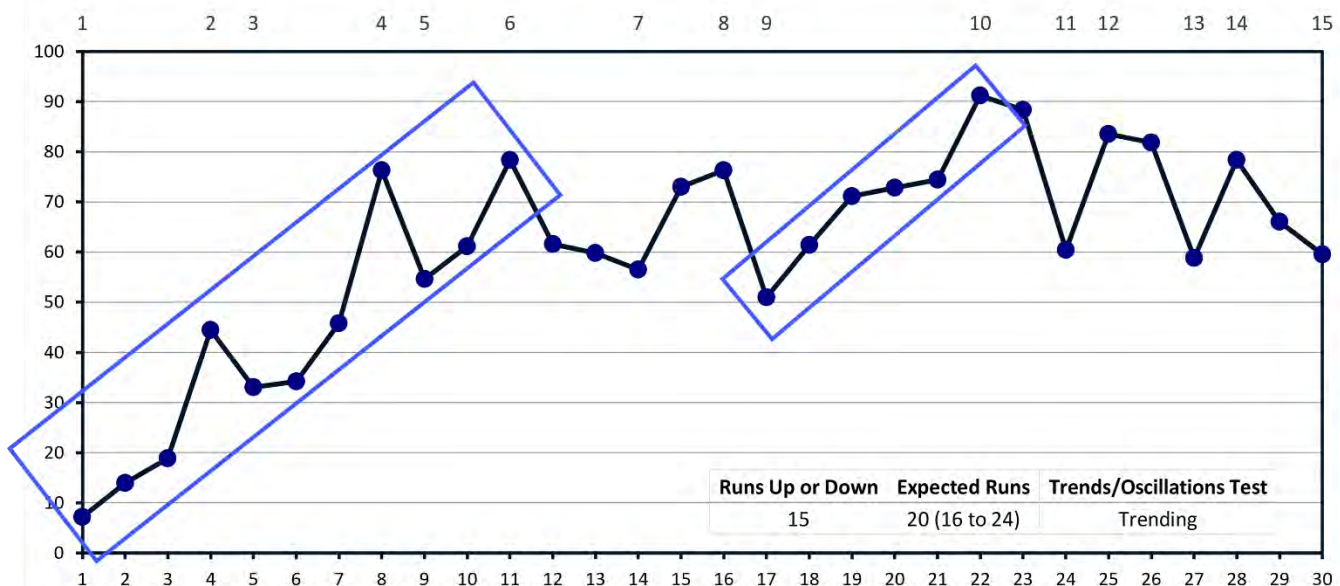
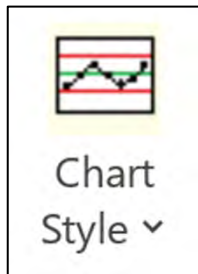


Figure 6.13 Trend

CHART STYLE



The Chart Style icon allows one to select the boldness style of the charts. The charts in the user guide are all made using the bold style.

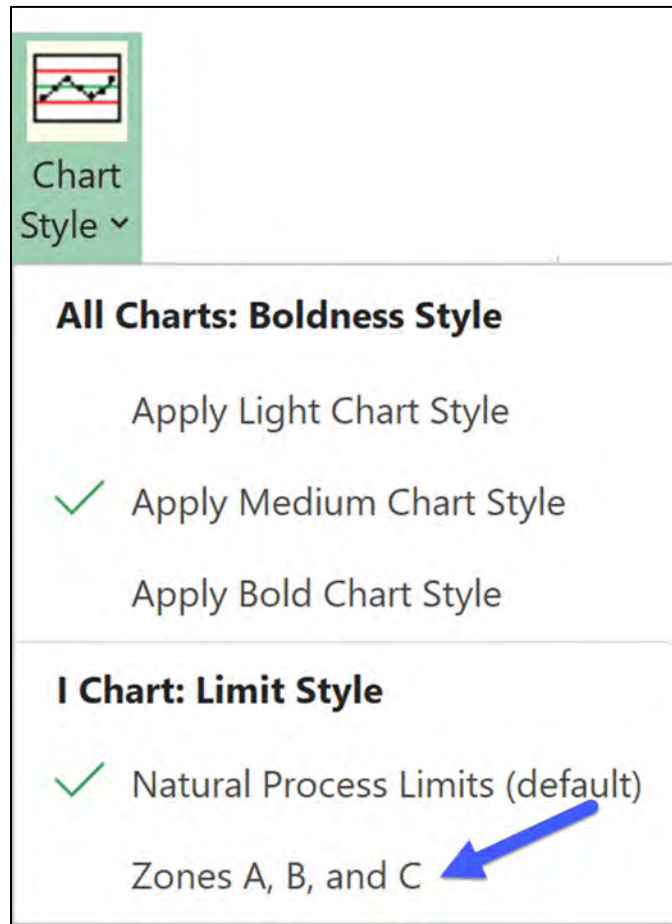


Figure 6.14 Chart Style Choices

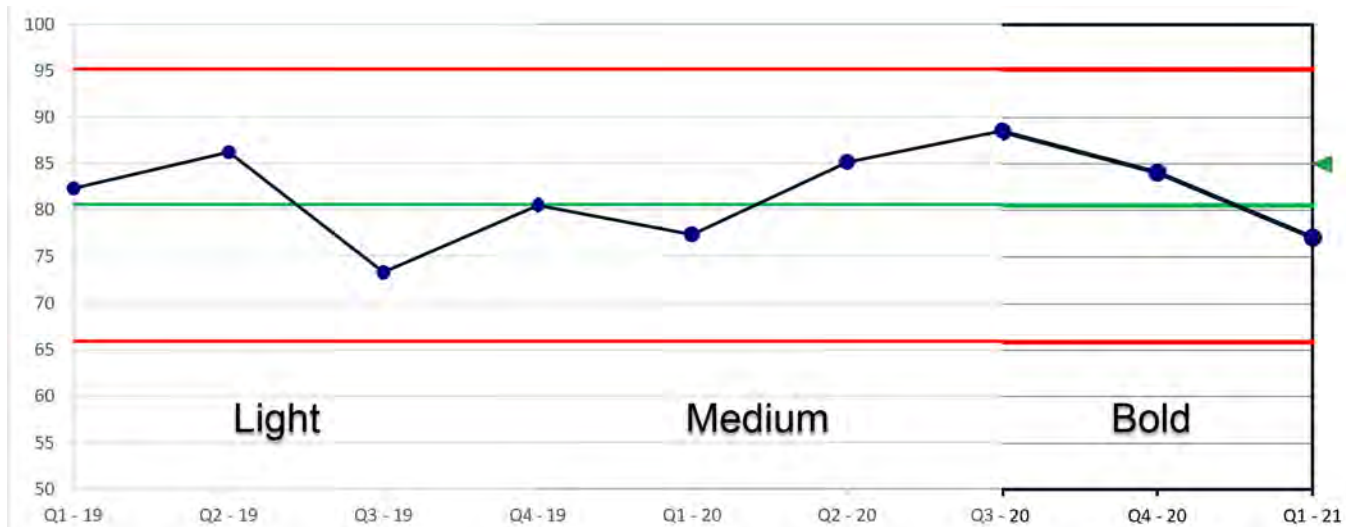


Figure 6.15 Chart Boldness Style.

In addition, you can show the zones that the Assignable Cause Patterns test are based on by selecting "[Zones A, B, and C](#)"



Figure 6.16 Chart with Zones

EXPORT CHARTS



The Export Charts icon allows exporting charts to Power Point and Word or saving as an Adobe PDF file or as a PNG image file.

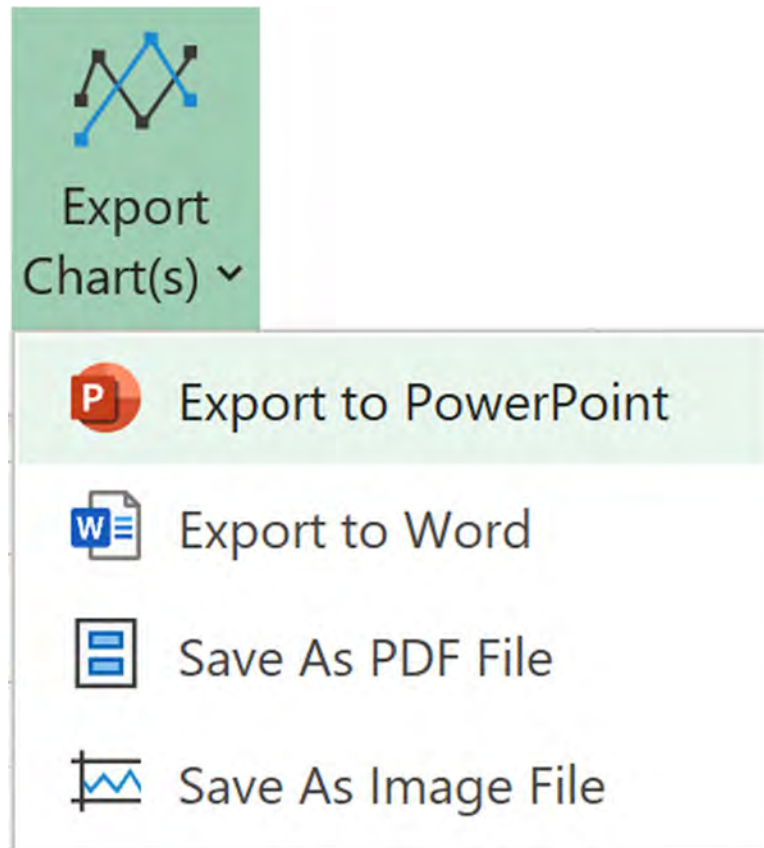
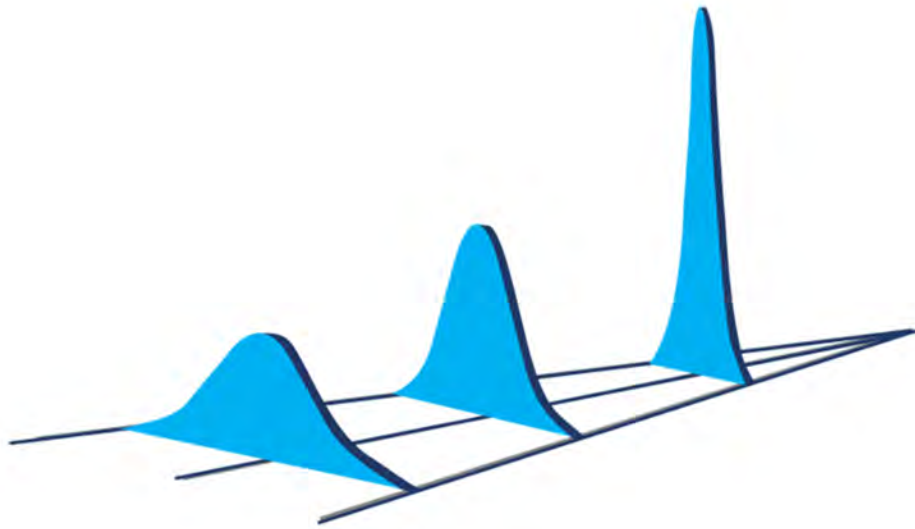


Figure 6.17 Export Charts selections.



Chapter 7

DASHBOARDS

SETTING UP MULTIPLE CHARTS ON ONE SCREEN OR ON ONE PAGE

This chapter will explore the nuances of the Dashboard procedure.

DASHBOARDS

A dashboard is a collection of Charts you can place and display on one printed page or on one computer screen. A couple of examples are shown on the next pages.

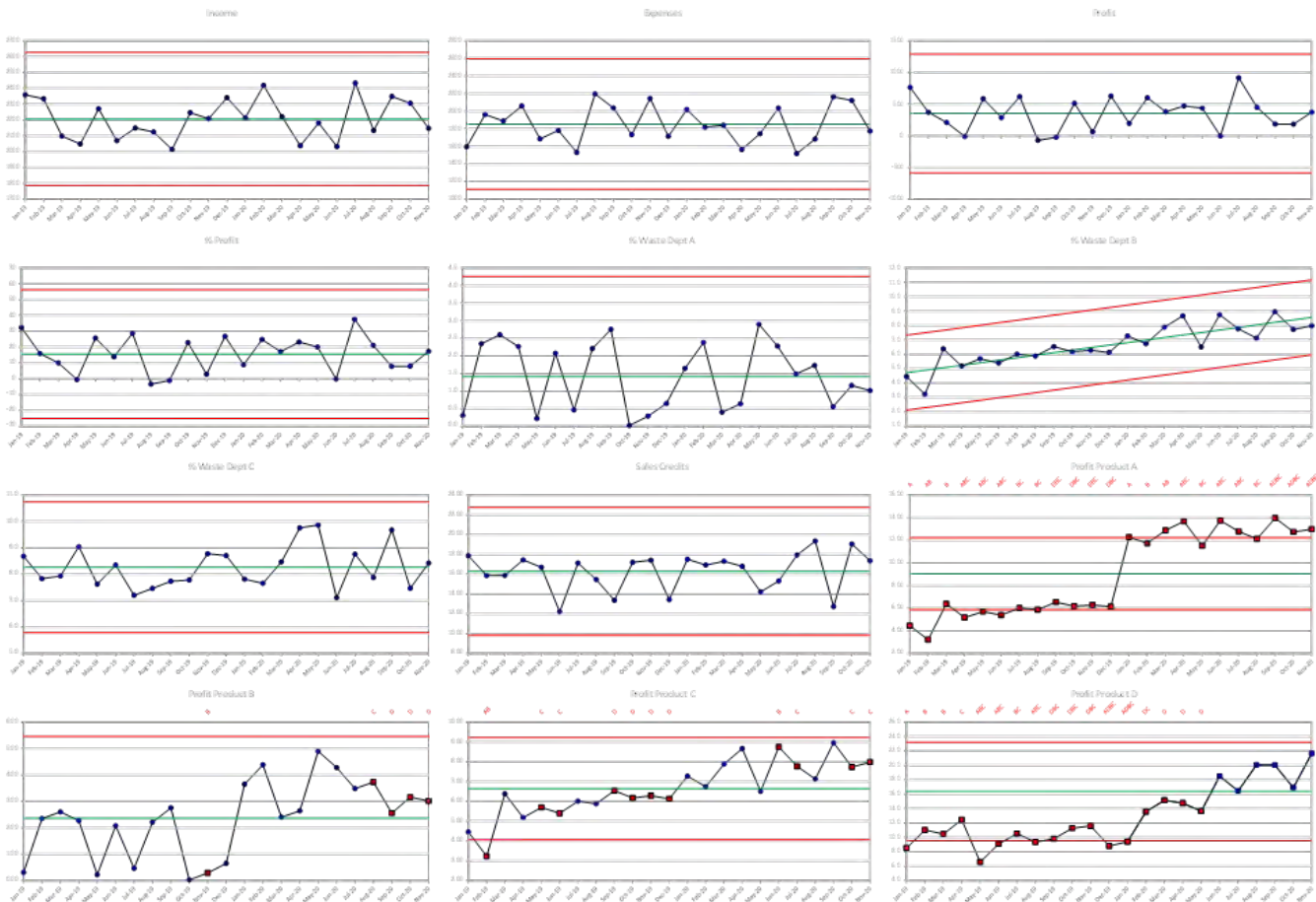


Figure 7.1 Business Expense Dashboard

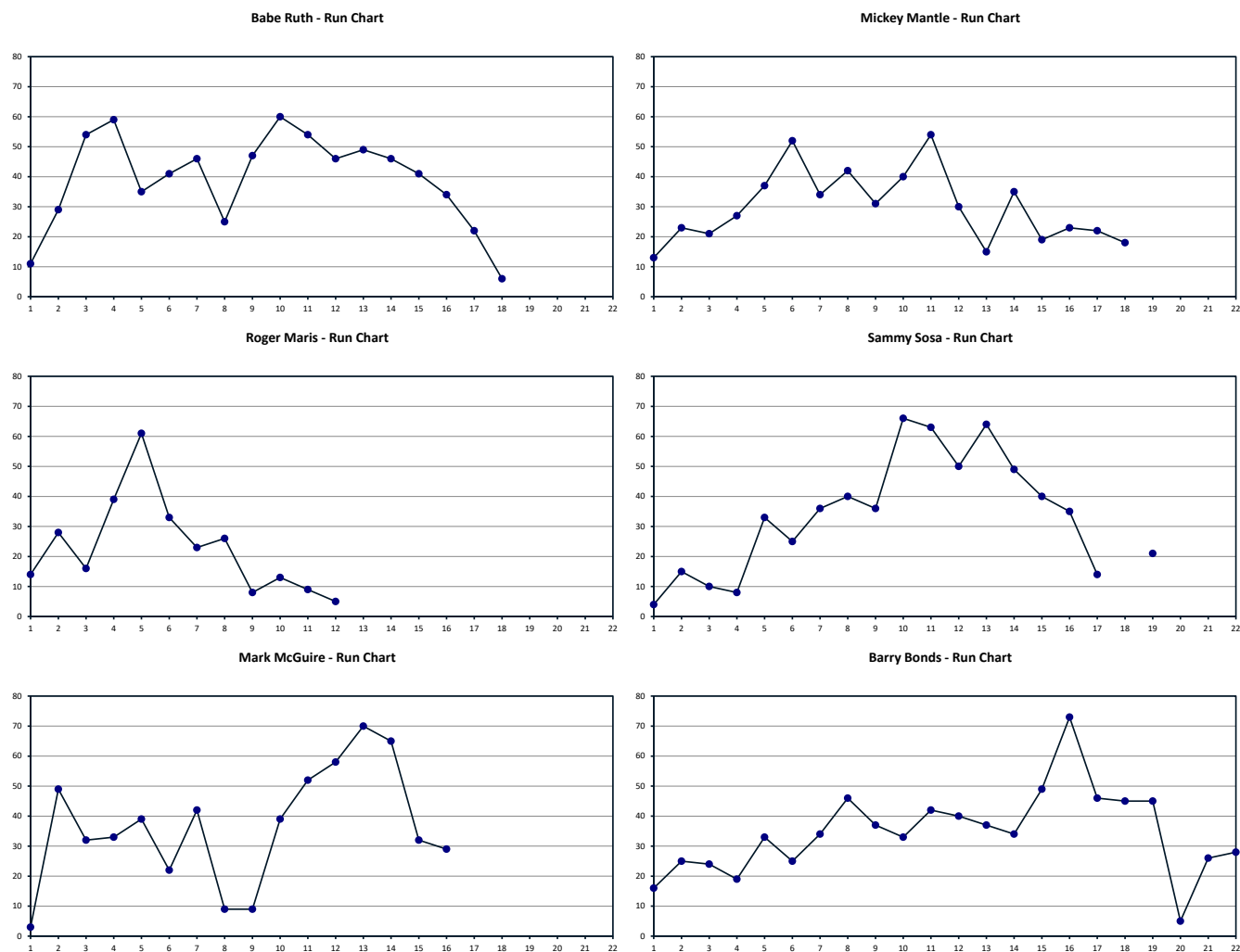


Figure 7.2 Baseball Dashboard

The Dashboard Designer icon has several features to help configure the best possible output.

A dashboard may contain an unlimited number of the same type of chart. Chart types cannot be mixed, you can select from an I, MR, Run, or I-MR Chart. Dashboards may be given titles that appear when printed.

The dashboard title serves an additional purpose, it becomes the name of the dashboard configuration file, all the specific customizations are saved in that file so that in the future you can recall and repeat the specific content of a dashboard. You can use the buttons at the bottom left of the Dashboard Designer dialog box to manage dashboards.

Formatting options include Portrait/Landscape orientation and a selection of a specific size paper where the location and size of the individual charts is optimized.

Individual charts are selected/deselected by clicking on them in the “**Available Columns:**” box. Once selected the chart appears in the “**Selected Columns:**” box in the order of selection. The buttons to the right of the “**Selected Columns:**” box allow customization of the order of the columns.

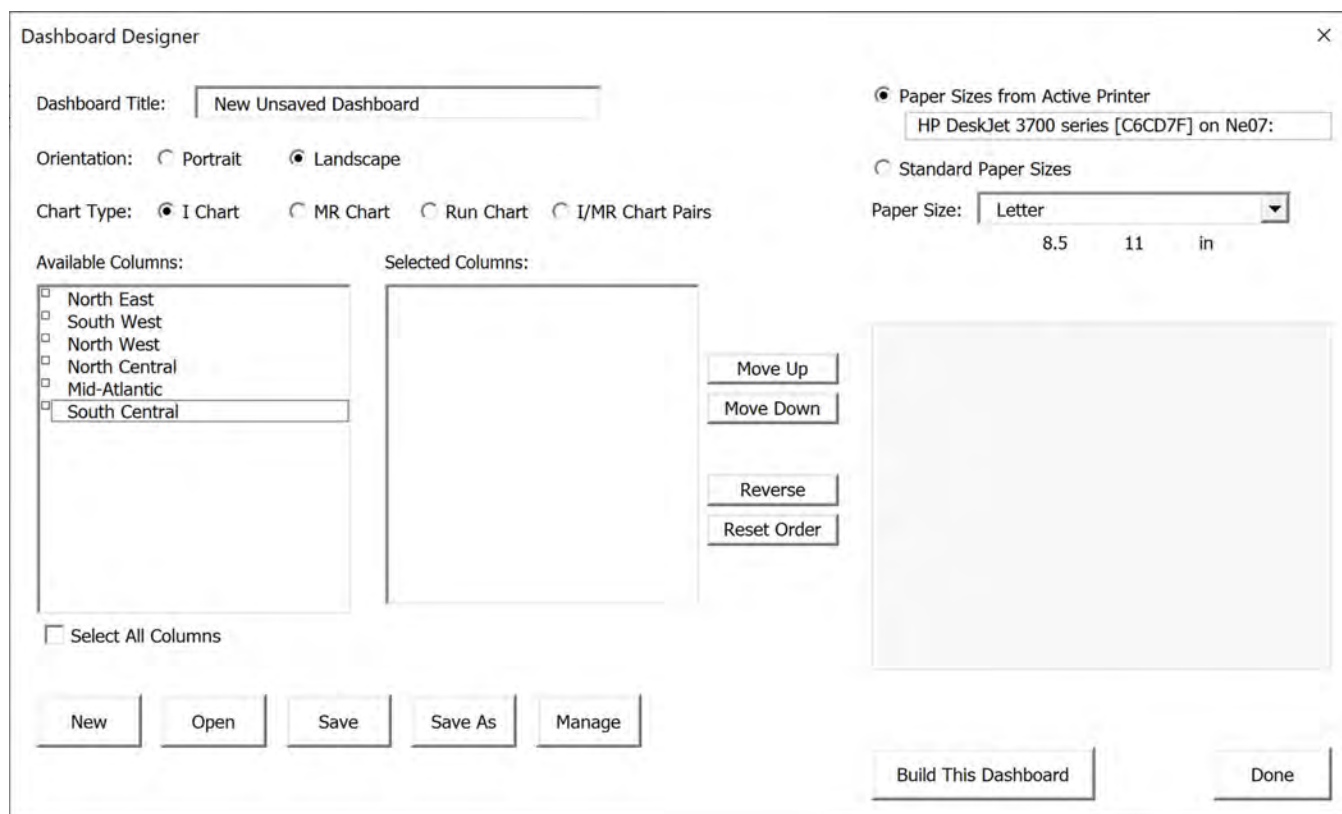


Figure 7.3 Dashboard Designer

Charts appear ordered from top to bottom, left to right.

A preview of the location of charts on the selected paper size for the selected printer appears in the bottom right of Figure 7.4.

Dashboards can be exported to Power Point, Word, PNG or pdf formats, however without titles see Figure 7.5.

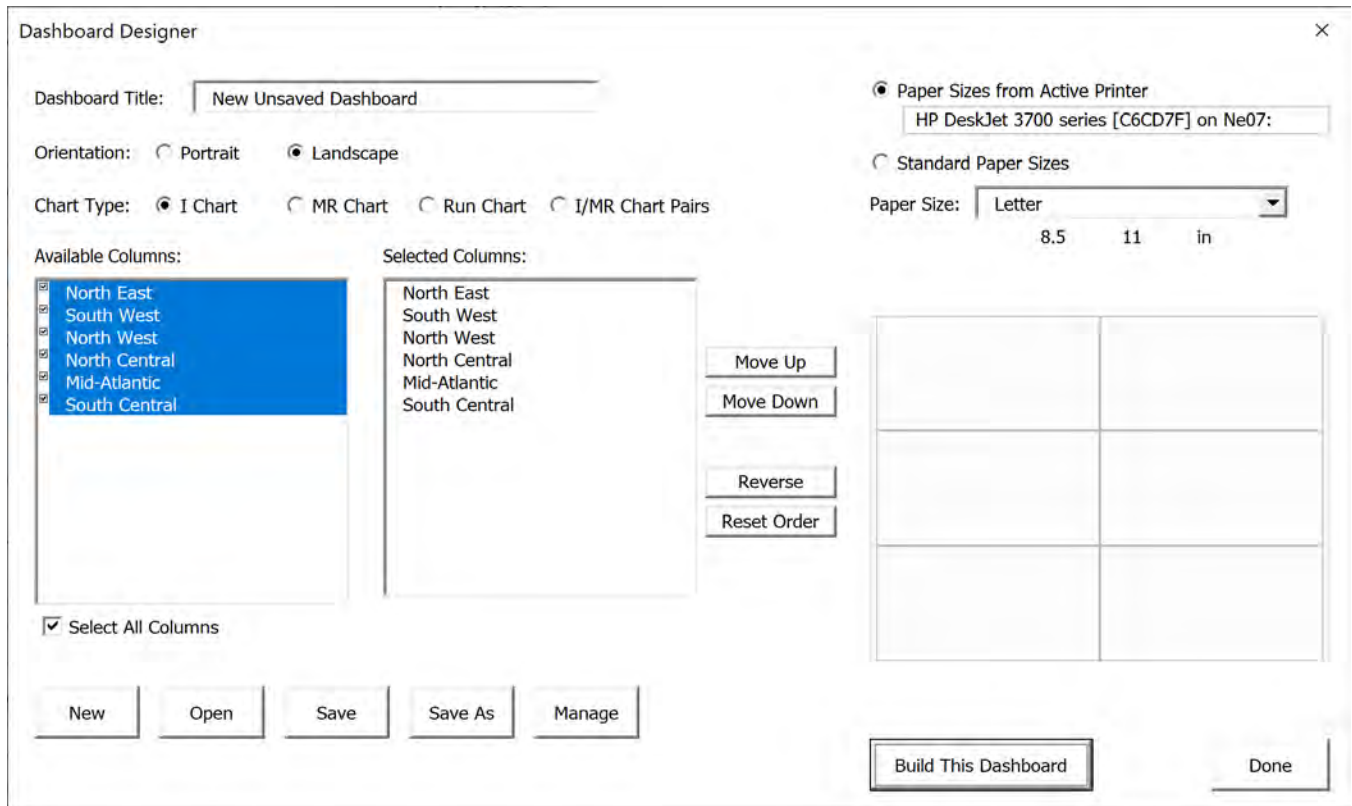


Figure 7.4 Selected and Ordered I Charts

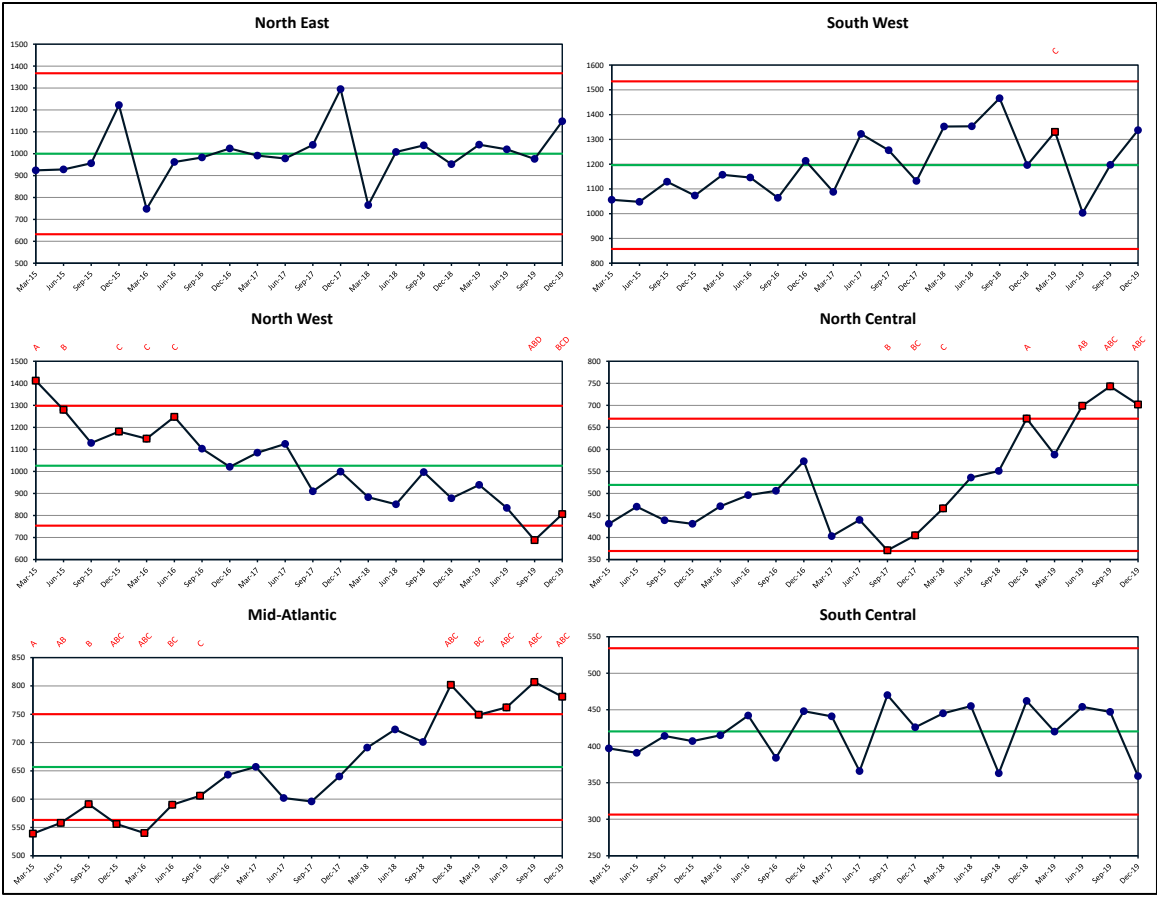


Figure 7.5 Exported Dashboard Image

If you want to retain a title you need to print to an Adobe file in the Excel print command, see Figure 7.6

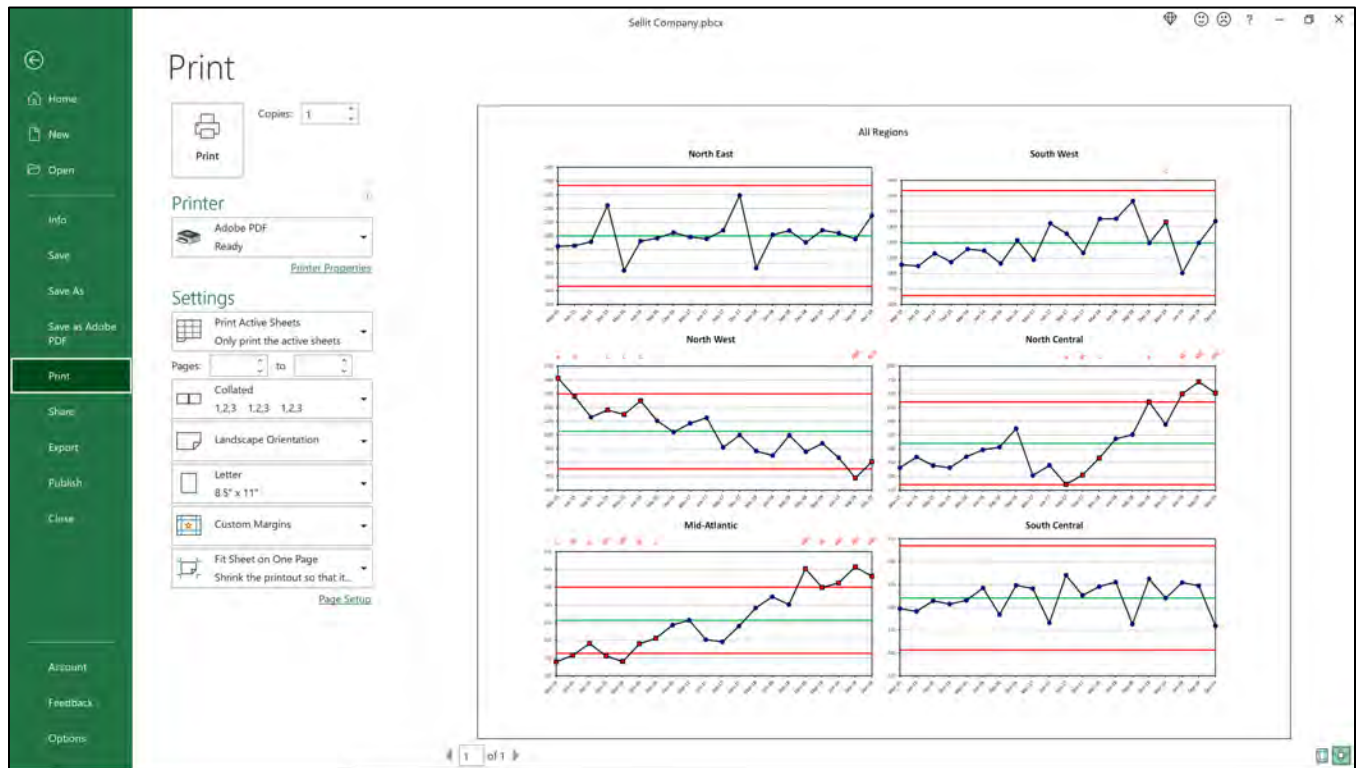


Figure 7.6 A Dashboard Printed to an Adobe file to retain the title

Dashboards are just pictures of the current state of the data when created, they do not automatically update. If you add new data to the Data worksheet tab, you will need to reproduce a dashboard by opening the desired Dashboard.

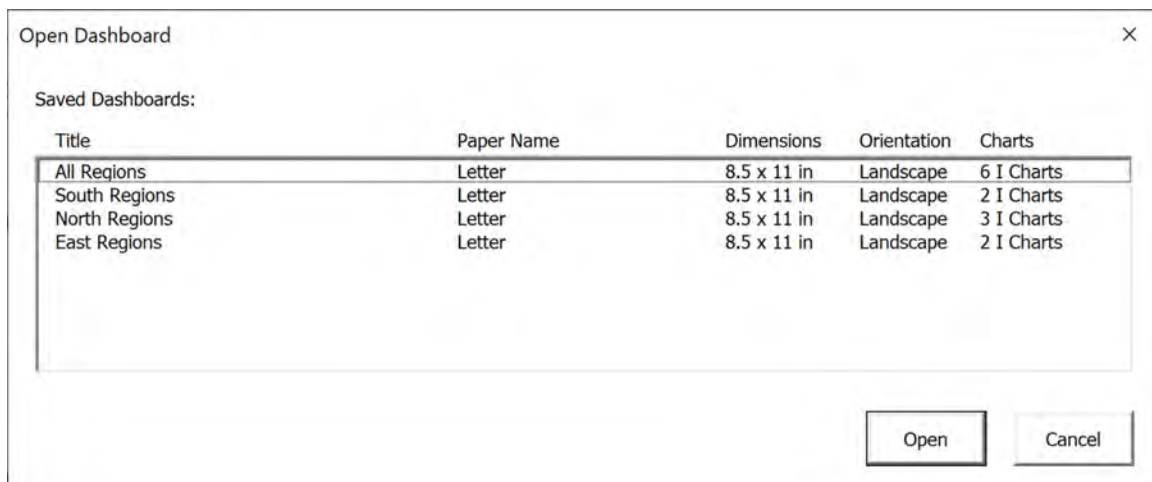


Figure 7.7 Opening a Dashboard

Another useful trick when one wants to compare the charts is to make all the Y Axis Ranges the same.

1. Predetermine the minimum and maximum values from all the individual charts.
2. Since Dashboards are not editable, open an editable worksheet tab, i.e. I Chart, MR Chart or Run Chart.
3. Select the Y Axis Scale button, and enter the Minimum and Maximum values and check the “[Apply this scale to all of your charts](#)” see below.

User-Defined Scale

Enter any or all axis scale parameters for your I charts.

Excel axis scale defaults will be used for items left blank.

	Data	User-Defined
Minimum	688	200
Maximum	1412	1600
Major Unit		

Clear All

☒ Apply this scale to all of your charts.

OK Cancel

Figure 7.8 Setting all dashboard charts with the same Y Axis value

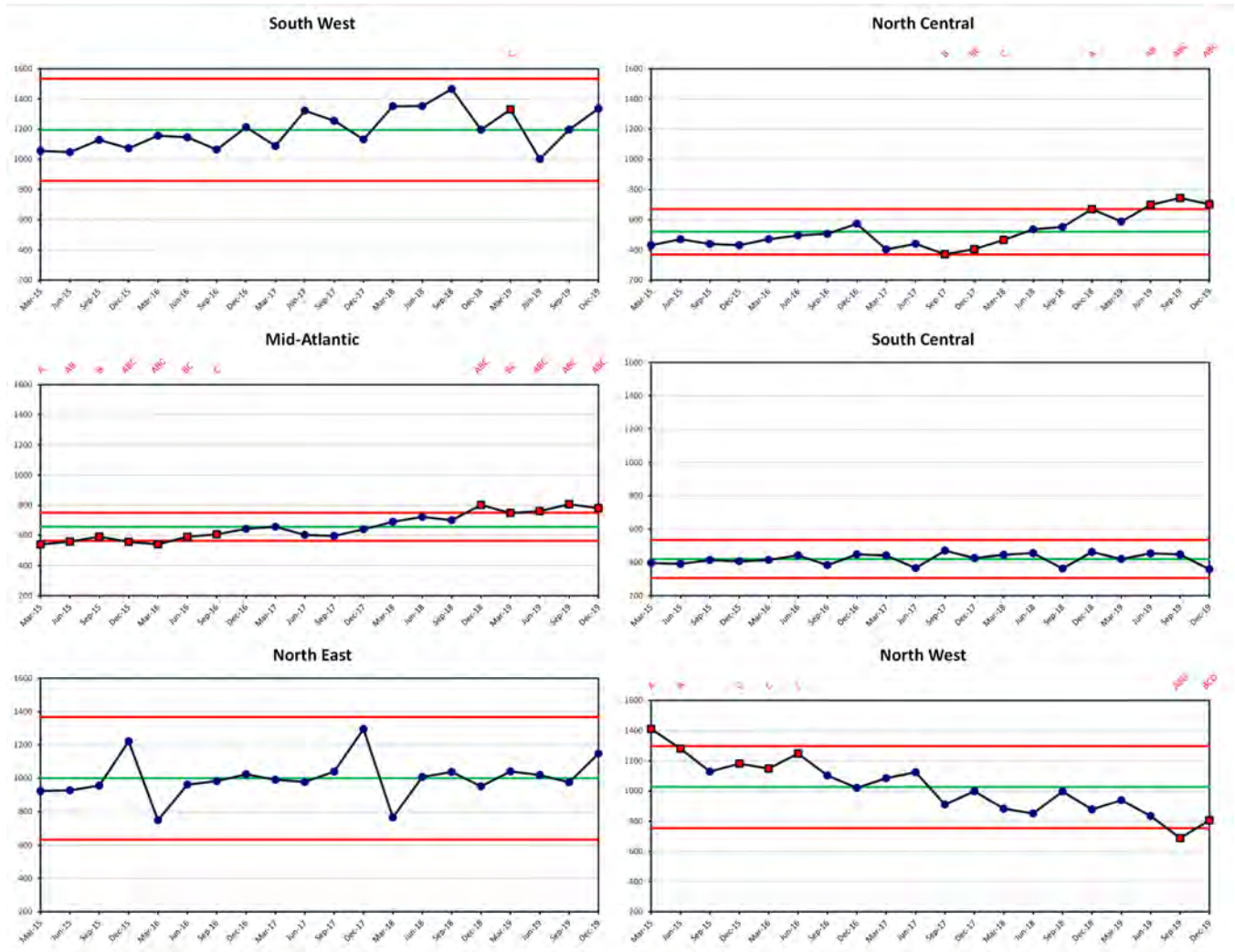
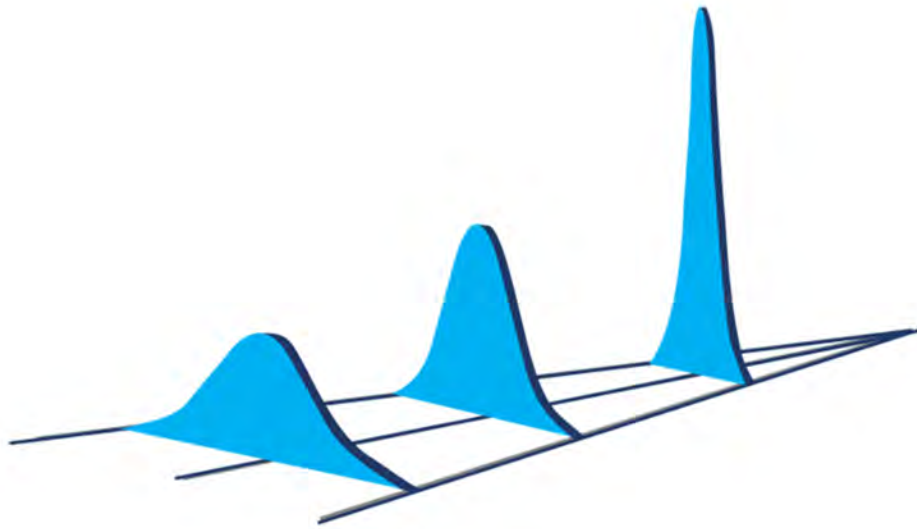


Figure 7.9 Comparing all charts with the same Y axis values

It's easy to see three of the regions are doing better than the other three. Also, of note only two of the regions are absent assignable cause pattern codes.



Chapter 8

OPTIONS GROUP

OTHER SETTINGS

ASSIGNABLE CAUSE PATTERN TESTS

Three items appear on the screen when you press the I Chart Worksheet Tab. On the Left side is the I Chart itself. On the top right is the I Chart parameter information. Assignable Cause Patterns Codes are shown on the bottom right side. Bolded Codes indicate which are active codes. The four bolded are the default patterns that Dr. Wheeler favors.

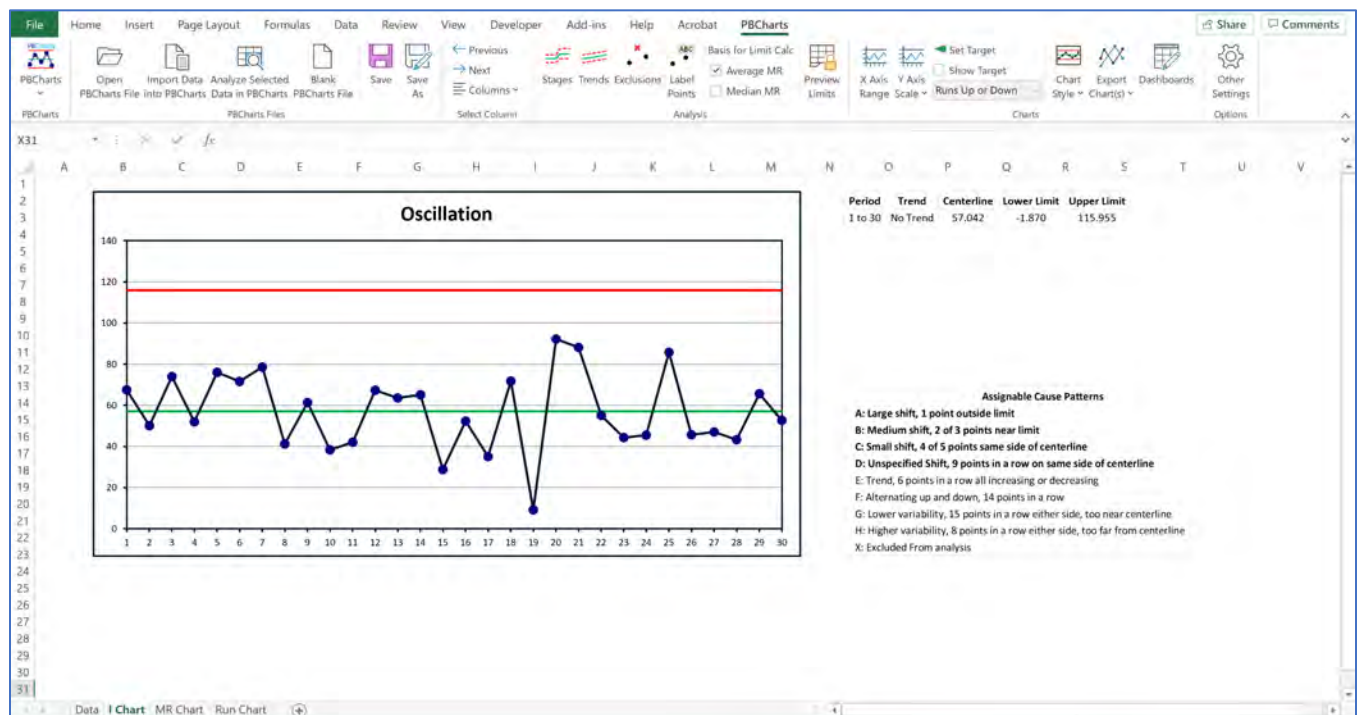


Figure 8.1 I Chart Worksheet Tab

To select a different set of Assignable Cause Patterns, press the “[Other Settings](#)” icon in the “Options” Group and then select the “[Choose Assignable Causes for I Charts](#).”

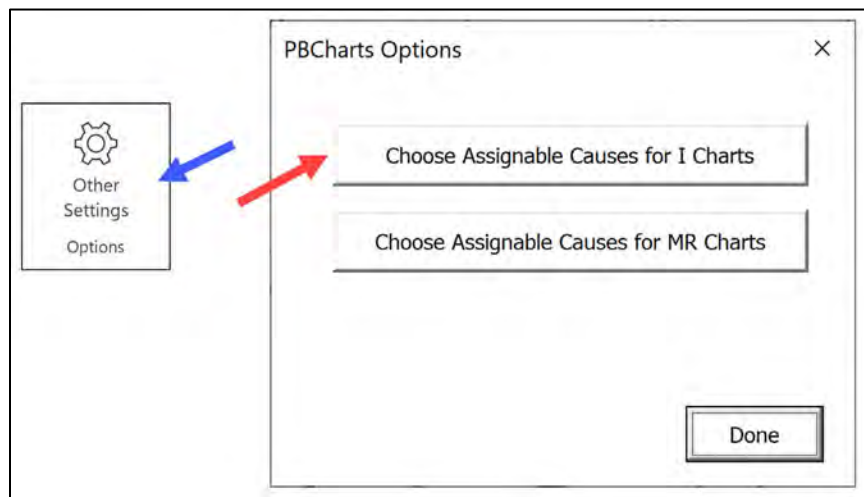


Figure 8.2 Selecting Assignable Cause Patterns for the I Chart

You can select all codes, no codes or any of the eight that are listed.

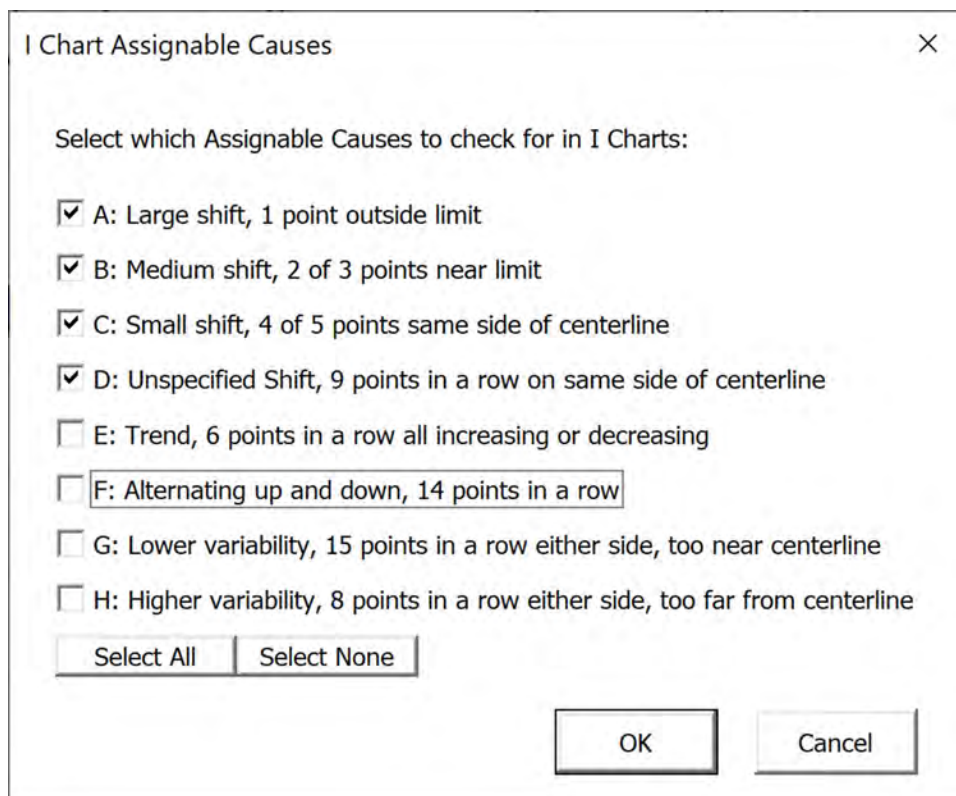
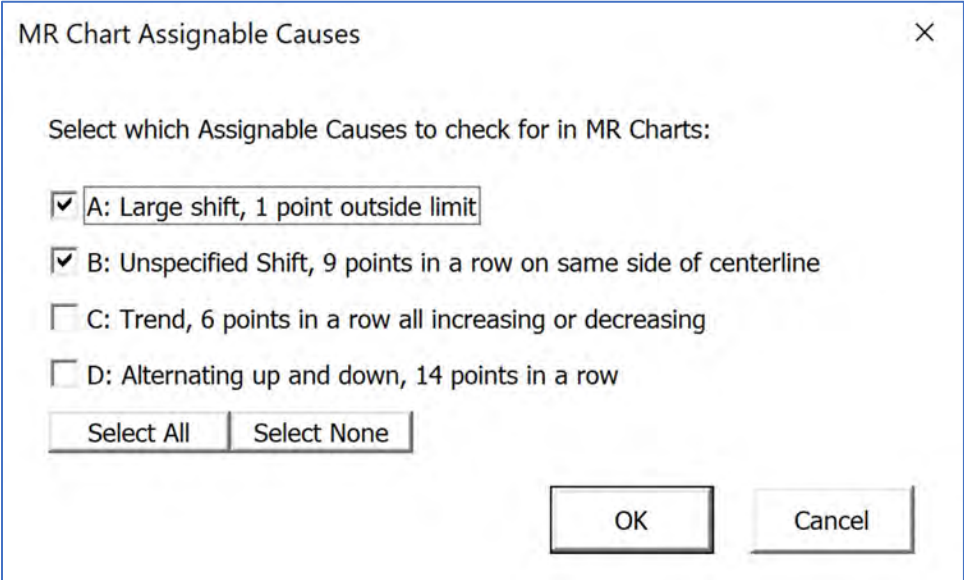


Figure 8.3 I Chart Assignable Causes

You can also select the Codes for the MR Chart.



MR Chart Assignable Causes

Select which Assignable Causes to check for in MR Charts:

- ☒ A: Large shift, 1 point outside limit
- ☒ B: Unspecified Shift, 9 points in a row on same side of centerline
- ☐ C: Trend, 6 points in a row all increasing or decreasing
- ☐ D: Alternating up and down, 14 points in a row

Select All Select None

OK Cancel

Figure 8.4 Assignable Cause Patterns for the MR Chart

Figure 8.8 through Figure 8.11 illustrate all the codes, and a more detailed description follows.

The codes are all based upon dividing the area between the natural process limits into six zones, see Figure 8.5 and Figure 8.7. The assignable cause patterns are statistically defined using the zones see Figure 8.8. The descriptions used in the PBCharts Assignable Cause Patterns table attempt to define the size of the shift displayed by the data rather than the exact statistical definition. It's important to know the number of points involved, because you can count back to see where the assignable cause pattern started.

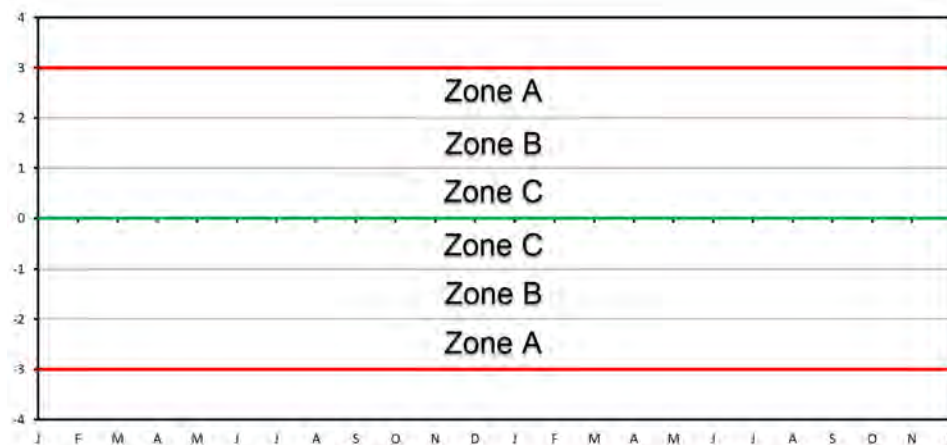


Figure 8.5 Dividing up the area between Natural Process Limits into 6 Zones

Select the “[Chart Style](#)” icon then select the “**One, Two Three Sigma Lines**” to help visualize the assignable cause pattern’s relationship to the six zones,.

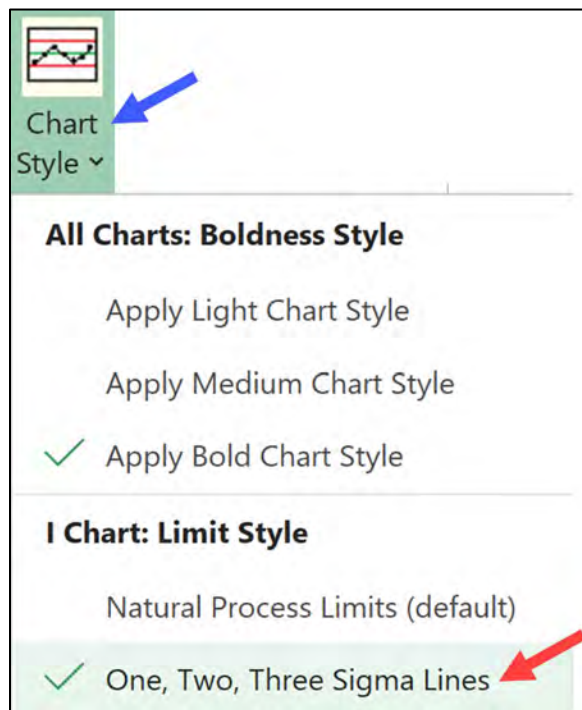


Figure 8.6 Selecting Zones

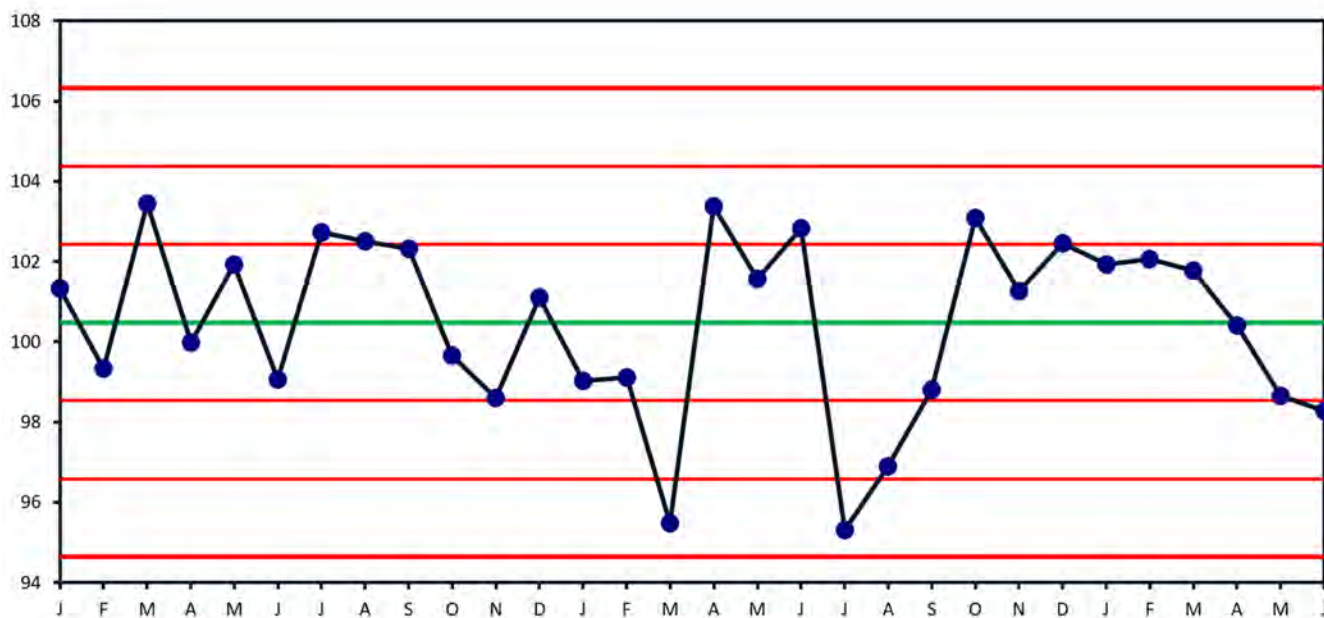


Figure 8.7 Adding Zones to an I Chart

CODE	PBCHARTS CAUSE DEFINITION	ASSIGNABLE ZONES DEFINITION
A	Large Shift 1 point outside limit	1 point beyond Zone A
B	Medium Shift 2 of 3 points near limit	2 out of 3 points in a row in Zone A or beyond
C	Small Shift 4 of 5 same side of centerline	4 out of 5 points in a row in Zone B or beyond
D	Unspecified size shift 9 points in a row same side of centerline	9 points in a row in Zone C or beyond on one side of the central line
E	Trend 6 points in a row all increasing or decreasing	6 points in a row steadily increasing or steadily decreasing
F	Alternating up and down 14 points in a row	14 in a row alternating up and down
G	Lower Variability 15 points in a row too near centerline	15 in a row in Zone C on either side of the central line
H	Higher Variability 8 points in a row either side, too far from centerline	8 points in a row on either or both sides of the central line with no points in Zone C

Figure 8.8 Assignable Cause Explanations

Illustrations of all the codes follow in Figure 8.9 through Figure 8.11.

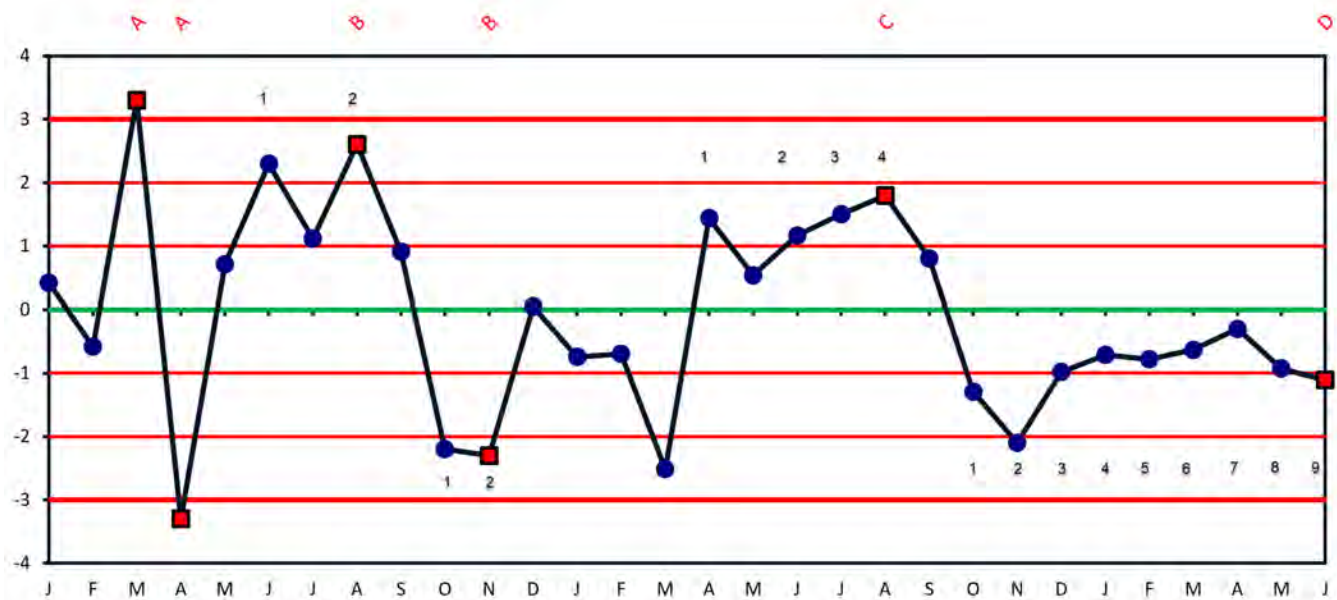


Figure 8.9 Assignable Cause Patterns A to D

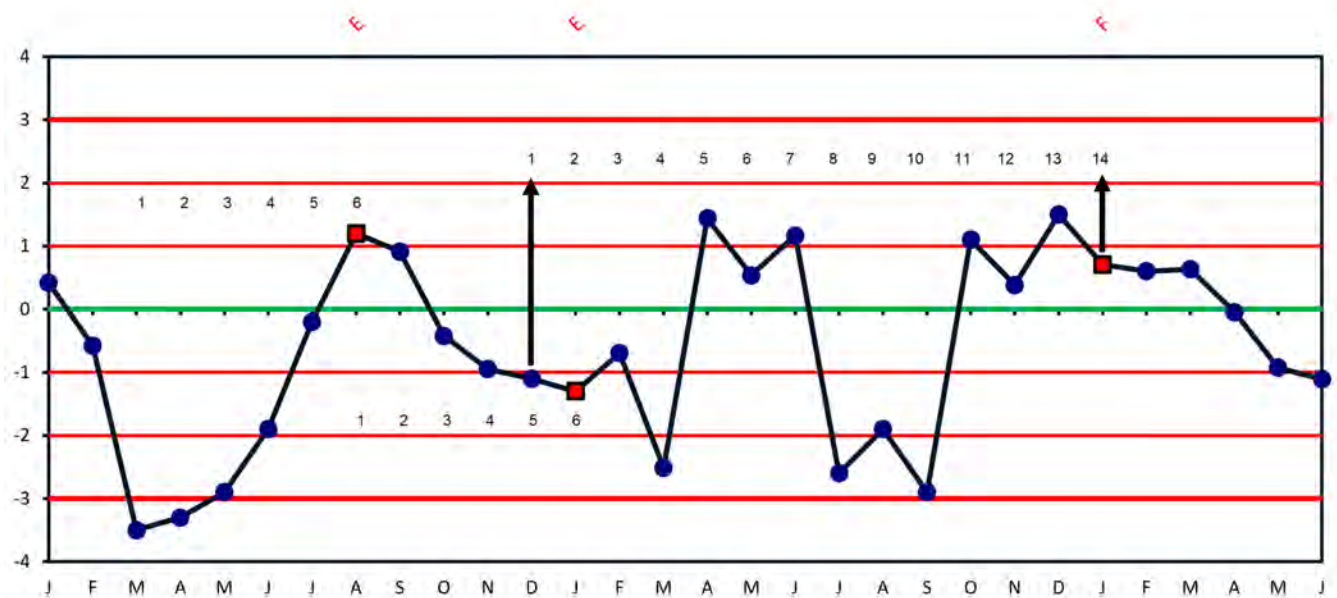


Figure 8.10 Assignable Cause Patterns E & F

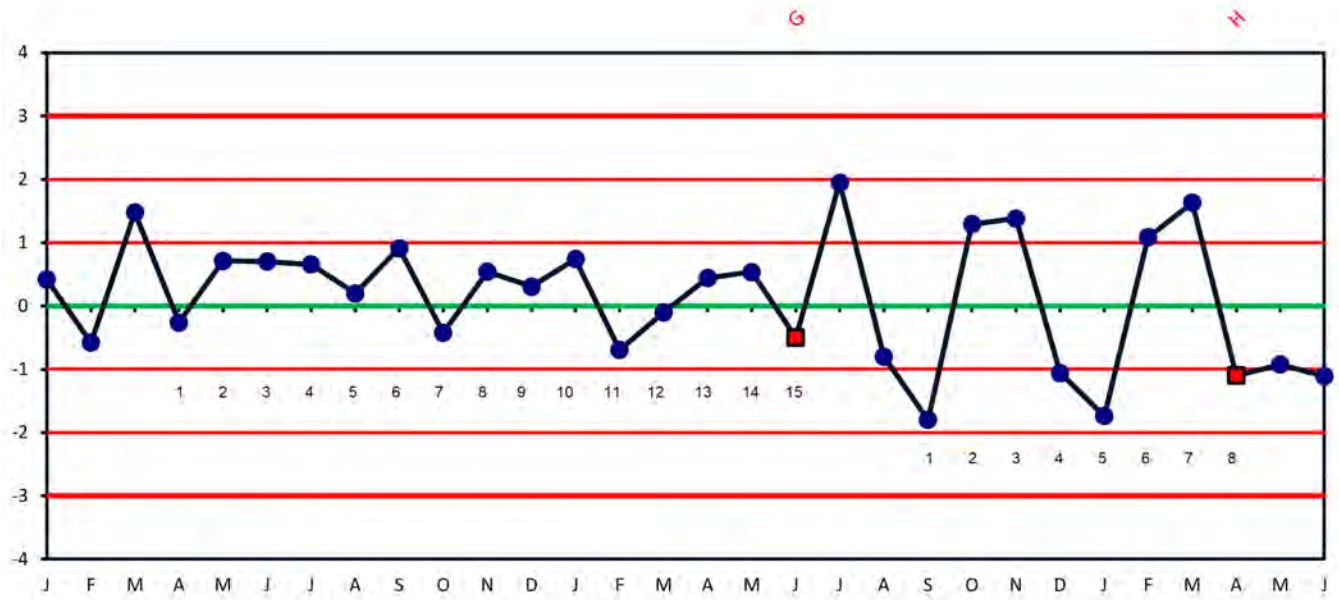
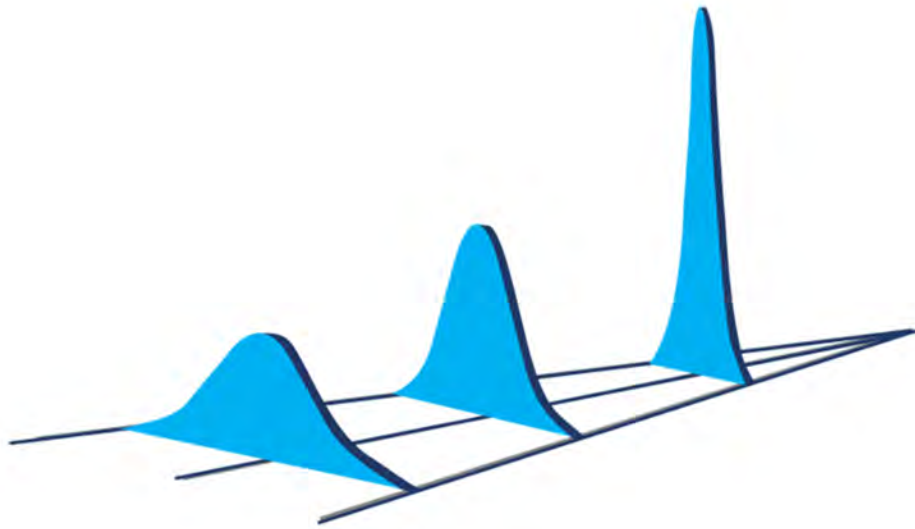


Figure 8.11 Assignable Cause Patterns G & H



Chapter 9

PBCHARTS WORKFLOW EXAMPLE

SELLIT COMPANY

The following is a story about George, a newly appointed Sales Manager for the Sellit Company⁵. The previous manager, Wesley, was fired because he was not able to meet his sales goals. In December 2018 after four years of poor sales results Wesley was given a final formal target of a 10% increase in total sales by the end of 2019. Figure 9.1 shows that Wesley didn't achieve the goal and was let go.

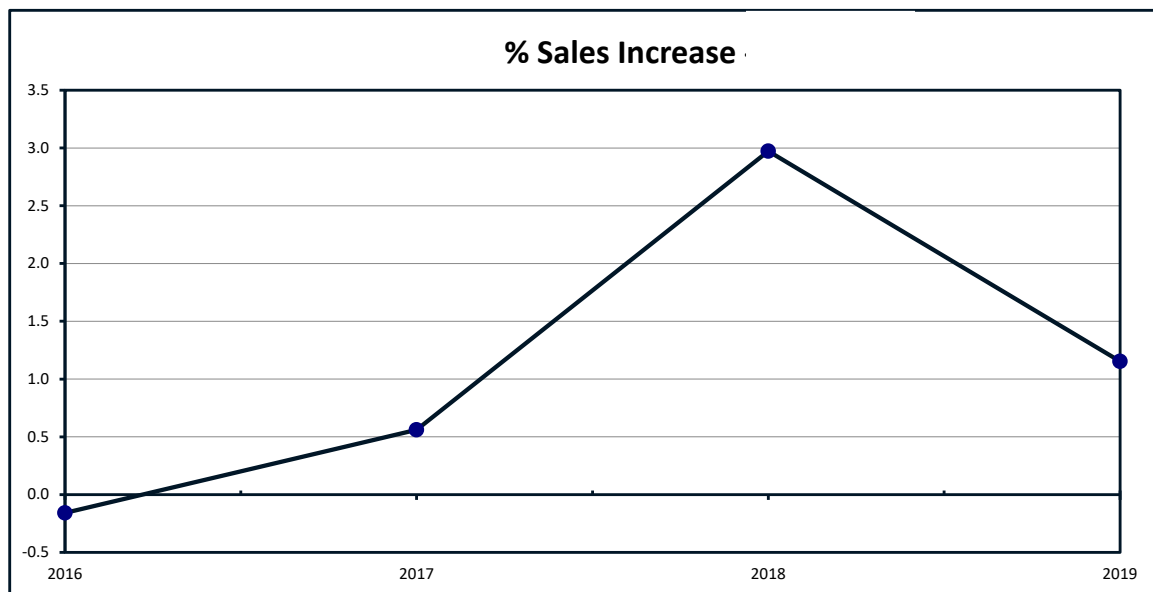


Figure 9.1 Wesley's Sales Increases

⁵ Thanks to Dr. Donald Wheeler for allowing us to use his data set which appears in Chapter Nine of his book *"Building Continual Improvement"* Second Edition, Donald J. Wheeler, Sheila R. Poling, ©2001 SPCPress, Knoxville TN, ISBN 0-945320-58-2

Wesley was a highly recommended sales manager noted for getting ten percent or higher sales growth by encouraging competition at all levels of the company and organizing extravagant annual sales contests. The higher the position the more extravagant the reward.

The 2019 reward trip for the winning Area Executive Vice President was a weeklong European River cruise down the Danube River costing \$12,500 plus airfare of \$3,000 per person and Sellit's President, Wesley, and the Area Executive Vice President and their spouses/guests were invited for a total expense of \$186,000. There were only two VPs so between themselves they chose to alternate trips every other year.

The 2019 trip for the winning Regional Vice President was a four-day winter skiing trip to the ski resort Vail at \$2,000/night plus \$1,500 airfare per person. Wesley, the appropriate Area Vice President and the winning Regional Vice President and their spouses/guests were invited for a total expense of \$57,000. The Regional VPs were more competitive than the Area VPs and the winner took all.

The 2019 trip for the winning Territory Manager was a two-day trip to New York City with Broadway Show tickets and dinner on both nights, for a cost of \$1,000 a night, and \$1,000 for air fare. Wesley, the appropriate Area VP, the appropriate Regional VP and the winning Territory Manager and their spouses/guests were invited for a total expense of \$24,000.

Wesley reorganized the company creating a new level of Executive Vice President, Figure 9.2, and brought in two of his cronies from his former employer a venture capital firm to fill the positions. He developed a matrix organization reassigning the three existing Regional Vice Presidents to report to both new Area Vice Presidents. Wesley felt this complex management system helped support the competitiveness needed to motivate the Territory Sales Managers to perform better.

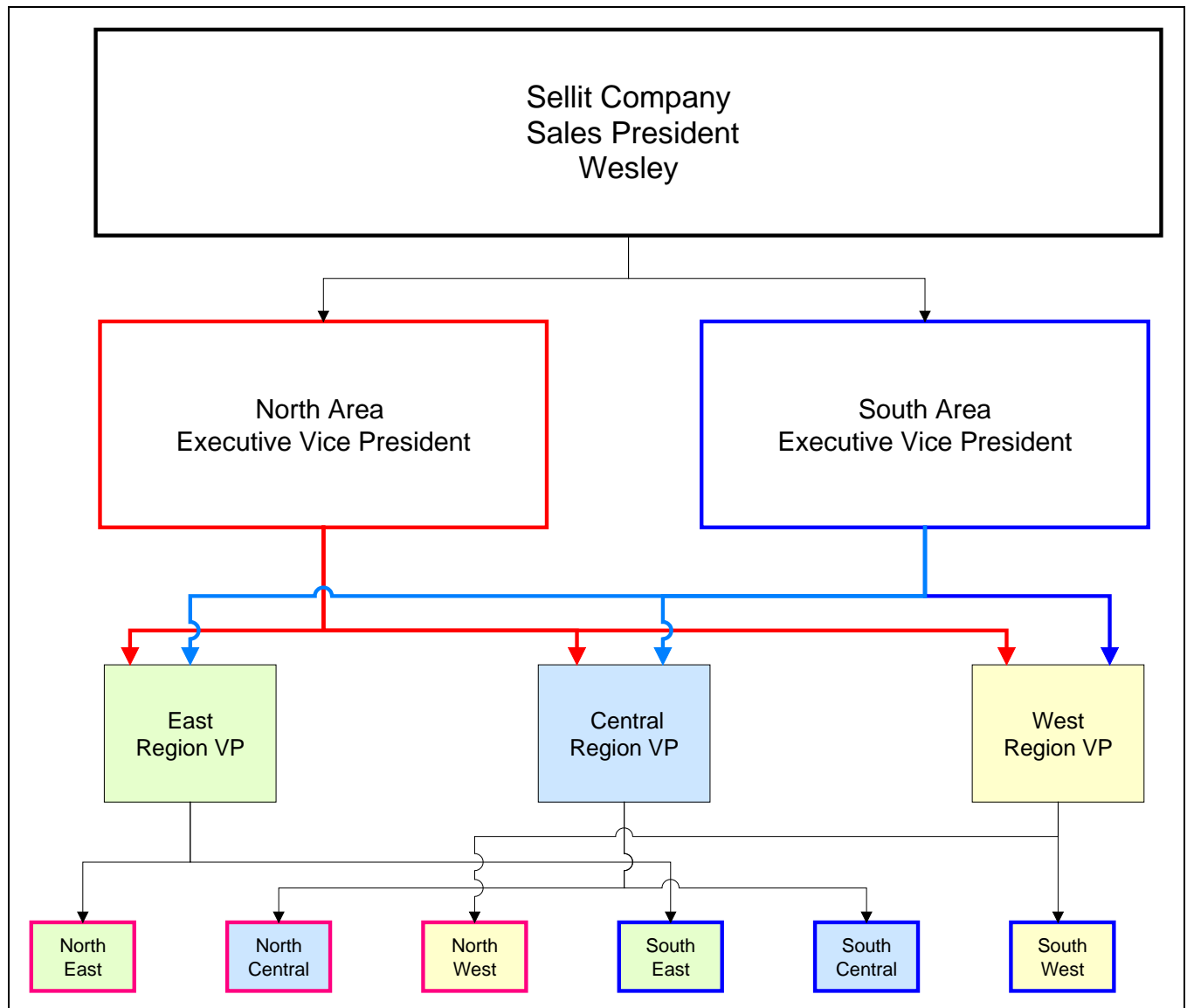


Figure 9.2 Wesley's Organization Chart

When George took over, he met with Gail, Sellit's chief financial officer and another Wesley hire. George asked for the latest quarterly figures. Gail delivered the report in person, Figure 9.3, so she could point out the losers that George ought to fire immediately, specifically the North West, South East, and South Central Territory Sales Managers. As evidence she showed Wesley's private score card, Figure 9.4. Wesley awarded points for the five two-point percentage comparisons highlighted in the Quarterly report. Two plus points for exceeding 10%, one plus point for a positive result between 0% and 10%, one negative point for results from 0 to negative 10% and minus two points for results worse than negative 10 %.

Gail's recommendations were based entirely on the negative scores from Wesley's latest score card gimmick.

Am I to understand the Regional Vice Presidents report to both Area Executive Vice Presidents? Yes, Gail said, Wesley set it up this way to encourage competition? I'm not sure that's a real benefit, said George.

George decided he needed to look a little deeper into the sales history and asked Gail for the sales figures by region for the last five years. That will take some time Gail said, I can get it to you next week, maybe. Two weeks later Gail gave George a spreadsheet with all the numbers he asked for, Figure 9.5.

George had attended a seminar, "Understanding Variation... An Executive Overview" by Donald Wheeler and had a handy copy of PBCharts software and decided to take a quick look at the sales data using PBCharts.

4th Quarter Report 2019												
Territories	4th Qtr 2019	3rd Qtr 2019	4th Qtr 2018	Quarterly Plan Value	% Diff from 3rd Qtr	% Diff from 2018	% Diff from Plan	Year-to-Date Values				2019 YTD as % Diff of 2018 YTD
								2019 Total	2018 Total	Plan	% Diff Plan	
North East	1148	976	952	1047	17.6	20.6	9.6	4185	3763	4139	1.1	11.2
North Central	702	743	670	737	-5.5	4.8	-4.7	2732	2223	2445	11.7	22.9
North West	806	688	878	966	17.2	-8.2	-16.5	3267	3609	3970	-17.7	-9.5
South East	781	807	802	882	-3.2	-2.6	-11.5	3099	2917	3209	-3.4	6.2
South Central	359	447	462	508	-19.7	-22.3	-29.4	1680	1725	1898	-11.5	-2.6
South West	1337	1197	1196	1316	11.7	11.8	1.6	4867	5367	5904	-17.6	-9.3
Areas	4th Qtr 2019	3rd Qtr 2019	4th Qtr 2018	Quarterly Plan Value	% Diff from 3rd Qtr	% Diff from 2018	% Diff from Plan	Year-to-Date Values				This YTD as % Diff of Last YTD
								2019 Total	2018 Total	Plan	% Diff Plan	
North	2656	2407	2500	2750	10.3	6.2	-3.4	10184	9595	10555	-3.5	6.1
South	2477	2451	2460	2706	1.1	0.7	-8.5	9646	10009	11010	-12.4	-3.6
Regions	4th Qtr 2019	3rd Qtr 2019	4th Qtr 2018	Quarterly Plan Value	% Diff from 3rd Qtr	% Diff from 2018	% Diff from Plan	Year-to-Date Values				This YTD as % Diff of Last YTD
								2019 Total	2018 Total	Plan	% Diff Plan	
East	1929	1783	1754	1929	8.2	10.0	0.0	7284	6680	7348	-0.9	9.0
Central	1061	1190	1132	1245	-10.8	-6.3	-14.8	4412	3948	4343	1.6	11.8
West	2143	1885	2074	2281	13.7	3.3	-6.1	8134	8976	9874	-17.6	-9.4
Sellit Company	4th Qtr 2019	3rd Qtr 2019	4th Qtr 2018	Quarterly Plan Value	% Diff from 3rd Qtr	% Diff from 2018	% Diff from Plan	Year-to-Date Values				This YTD as % Diff of Last YTD
								2019 Total	2018 Total	Plan	% Diff Plan	
Total	5133	4858	4960	5456	5.7	3.5	-5.9	19830	19604	21564	-8.0	1.2
	Represents good values greater than 10%											
	Represents potential problem areas with values between minus 5 and minus 10%											
	Represents bad values larger than minus 10%											

Figure 9.3 Sales Report for 2019

4th Quarter Report 2019						
Territories	% Diff from 3rd Qtr	% Diff from 2018	% Diff from Plan	% Diff Plan	2019 YTD as % Diff of 2018 YTD	Score
North East	+2	+2	+1	+1	+2	+8
North Central	-1	+1	-1	+2	+2	+3
South West	+2	+2	+1	-2	-1	+2
North West	+2	-1	-2	-2	-1	-4
South East	-1	-1	-2	-1	+1	-4
South Central	-2	-2	-2	-2	-1	-9
Areas	% Diff from 3rd Qtr	% Diff from 2018	% Diff from Plan	% Diff Plan	This YTD as % Diff of Last YTD	Score
North	+2	+1	-1	-1	+1	+2
South	+1	+1	-1	-2	-1	-2
Regions	% Diff from 3rd Qtr	% Diff from 2018	% Diff from Plan	% Diff Plan	This YTD as % Diff of Last YTD	Score
East	+1	+2	+1	-1	+1	+4
West	+2	+1	-1	-2	-1	+1
Central	-2	-1	-2	+1	+2	-2
Sellit Company	% Diff from 3rd Qtr	% Diff from 2018	% Diff from Plan	% Diff Plan	This YTD as % Diff of Last YTD	Score
Total	+1	+1	-1	-1	+1	+1

Figure 9.4 Wesley's Score Card

Quarter	North East	North Central	North West	South East	South Central	South West	North	South	East	Central	West	Total
Mar-15	924	431	1412	539	397	1056	2767	1992	1463	828	2468	4759
Jun-15	928	470	1280	558	391	1048	2678	1997	1486	861	2328	4675
Sep-15	956	439	1129	591	414	1129	2524	2134	1547	853	2258	4658
Dec-15	1222	431	1181	556	407	1073	2834	2036	1778	838	2254	4870
Mar-16	748	471	1149	540	415	1157	2368	2112	1288	886	2306	4480
Jun-16	962	496	1248	590	442	1146	2706	2178	1552	938	2394	4884
Sep-16	983	506	1103	606	384	1064	2592	2054	1589	890	2167	4646
Dec-16	1024	573	1021	643	448	1213	2618	2304	1667	1021	2234	4922
Mar-17	991	403	1085	657	441	1088	2479	2186	1648	844	2173	4665
Jun-17	978	440	1125	602	366	1322	2543	2290	1580	806	2447	4833
Sep-17	1040	371	910	596	470	1256	2321	2322	1636	841	2166	4643
Dec-17	1295	405	999	640	426	1132	2699	2198	1935	831	2131	4897
Mar-18	765	466	883	691	445	1352	2114	2488	1456	911	2235	4602
Jun-18	1008	536	851	723	455	1353	2395	2531	1731	991	2204	4926
Sep-18	1038	551	997	701	363	1466	2586	2530	1739	914	2463	5116
Dec-18	952	670	878	802	462	1196	2500	2460	1754	1132	2074	4960
Mar-19	1041	588	939	749	420	1330	2568	2499	1790	1008	2269	5067
Jun-19	1020	699	834	762	454	1003	2553	2219	1782	1153	1837	4772
Sep-19	976	743	688	807	447	1197	2407	2451	1783	1190	1885	4858
Dec-19	1148	702	806	781	359	1337	2656	2477	1929	1061	2143	5133

Figure 9.5 Five Years Sales Figures.

Wesley opened the Excel Spreadsheet given to him, went to the PBCgarts ribbon and pressed the “Analyze Selected Data in BP Charts” icon, Figure 9.6. and saved the data as a PBCcharts data file, Figure 9.7.

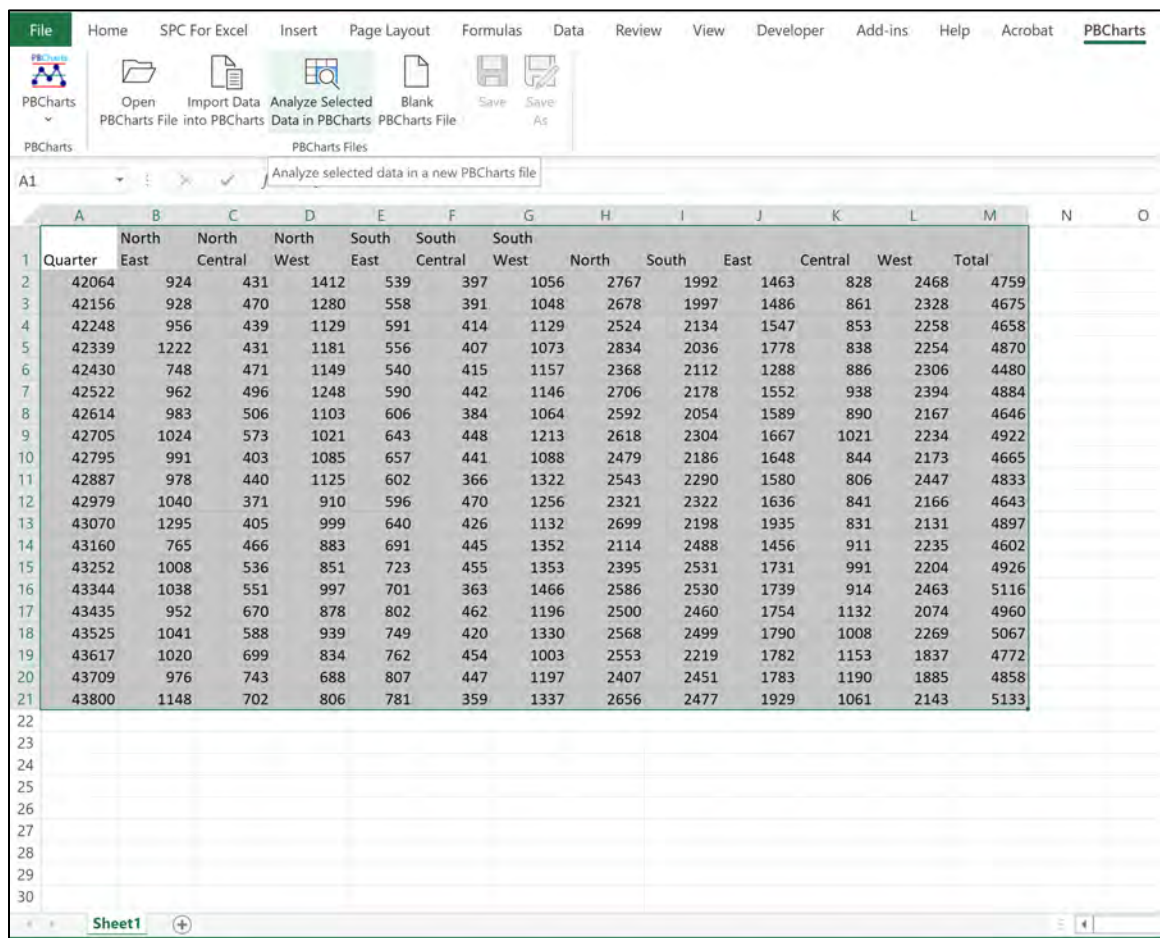


Figure 9.6 Opening Sales Data in PBCcharts

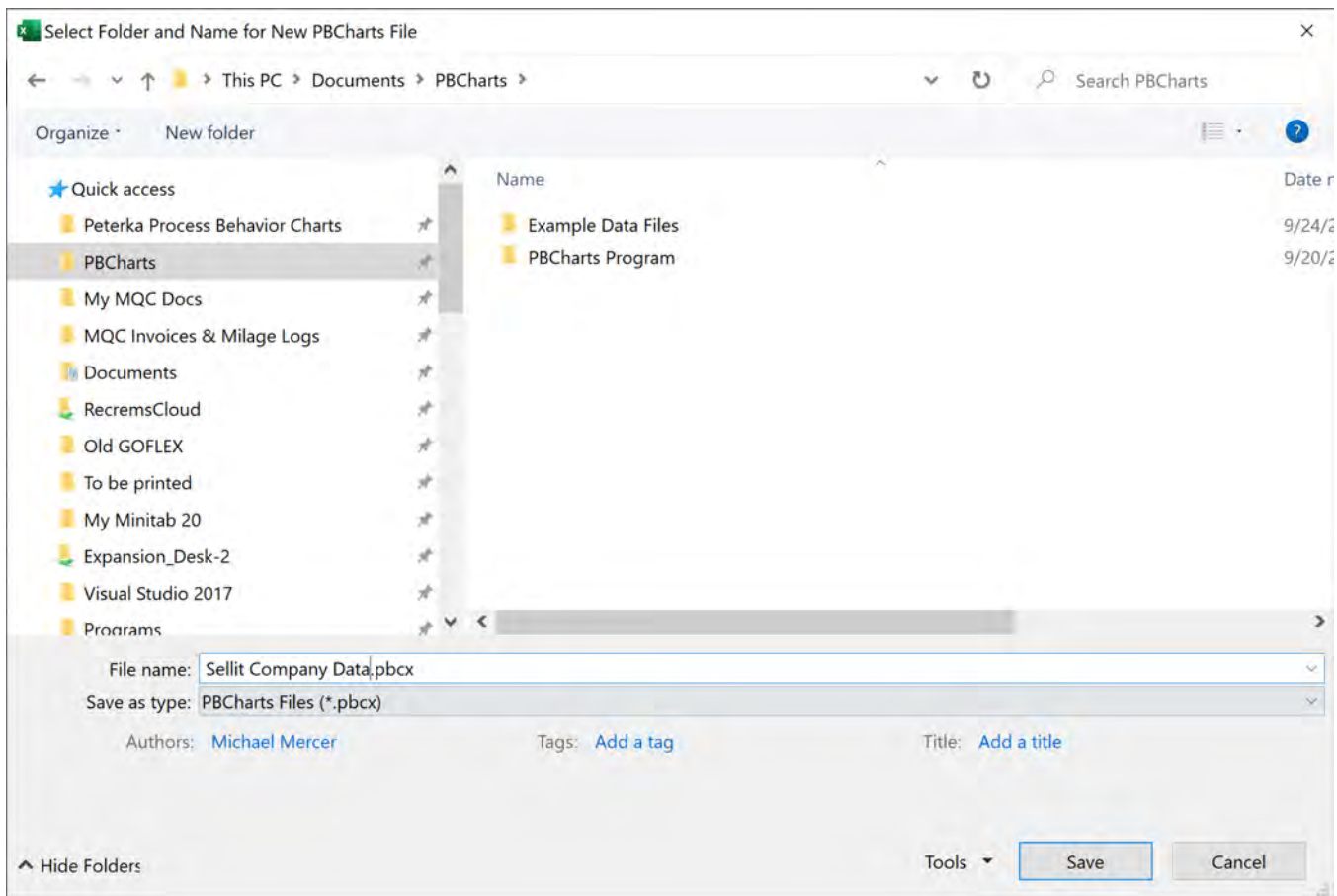


Figure 9.7 Saving Sales Data as a PBCharts data file

George decided to look at the run charts of the territories in the order of the highest points from Wesley's Score Card. The best territory according to Wesley was the North East.

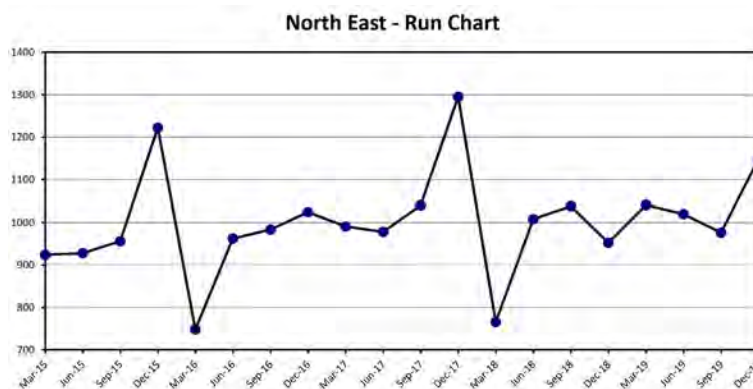


Figure 9.8 - North East Sales Result.

Boy! This person knows how to game the system, thought George. Every two years he arranges to move sales from the first quarter of next year into the last quarter of the present year, setting himself up for big awards. And he doesn't do it every year afraid people might catch on.

While the territory has the second highest total sales the data shows no improvement in results, pretty much the same year in and year out.

George thought, I can't wait to see the next territory, North Central.

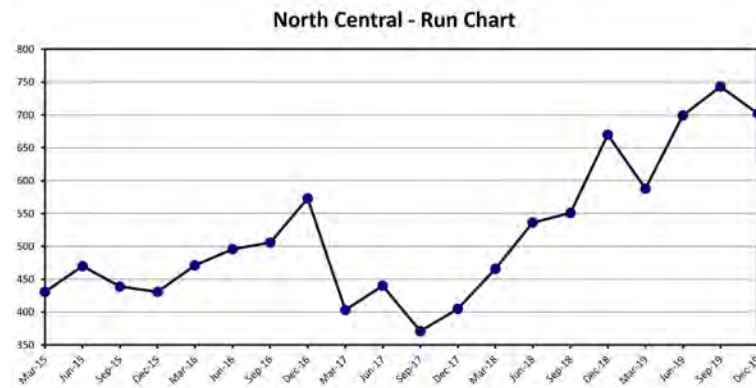


Figure 9.9 North Central Doubled Sales in Two Years

Wow! This territory has made major sales increases since the new Territory Manager took over in Sep-17. I wonder why it isn't first.

Next came the South West Territory.

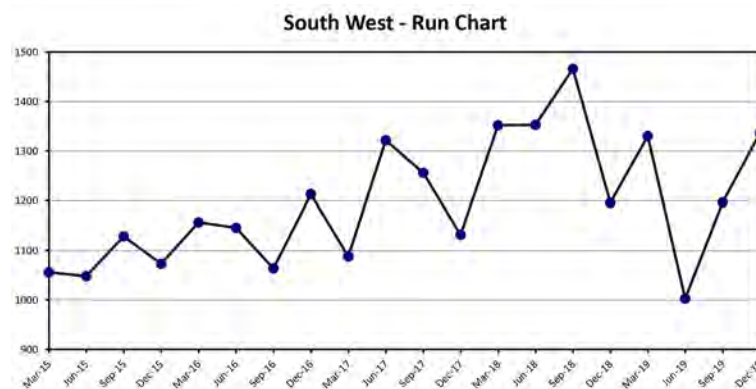


Figure 9.10 South West is Recently Declining

This territory is recently declining, how in the world did it come in third?

Next came the North West Territory where the biggest customer is Boeing Aircraft.

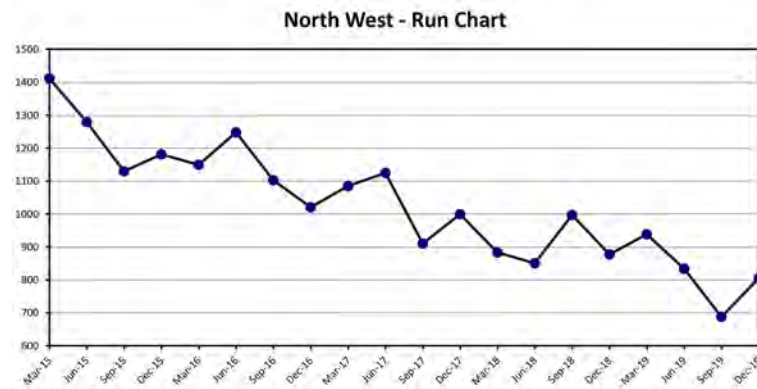


Figure 9.11 North West has dropped 50% in Five Years

Well, I see why Gail recommended firing this territory manager. But I wonder if the five-year decline of the Aerospace Industry is the reason for this result? I'll have to look more closely at these numbers.

Another big surprise when George viewed the South East territory.

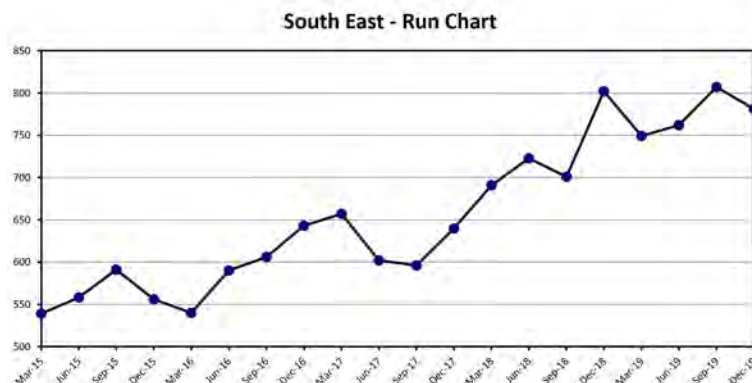


Figure 9.12 South East has grown 65% in Five Years but Maybe is Topping Off

Boy I wouldn't take Gail's advice and fire this territory manager, the business is grown about 165% in five years but is showing a couple of quarters of decline here and there, including most recently.. I wonder if 2019 was one of those declines and maybe 2020 is set for another big year.

The final territory is the newest, South Central.

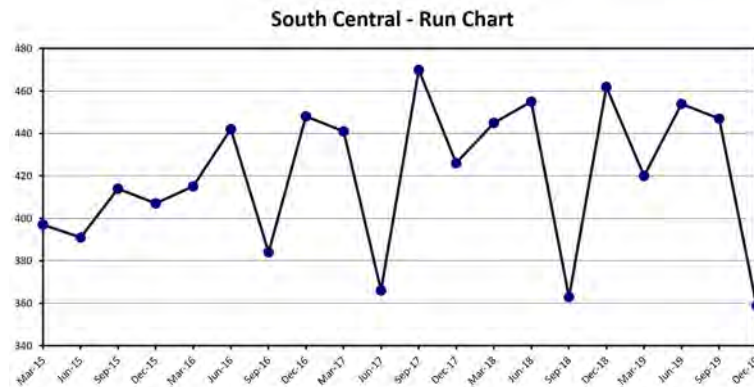


Figure 9.13 South Central Erratic Growth

South Central has the smallest sales volume and was showing 15% growth early on, but it is very erratic, especially the last quarter which greatly influenced Wesley's score card. Lots of work to do to discover the big picture.

Before discussing the territory charts with the North and South Area Executive Vice Presidents, George decided to look at the performance of their areas. He used the dashboard to view both Run Charts using the same Y Axis values. First he assigned the Y Axis a minimum of 1800 and a maximum of 3000 and checked the **"Apply this Scale..."**

User-Defined Scale

Enter any or all axis scale parameters for your Run charts.
Excel axis scale defaults will be used for items left blank.

	Data	User-Defined
Minimum	1992	1800
Maximum	2531	3000
Major Unit		

☒ Apply this scale to all of your charts.

OK Cancel

Figure 9.14 Assigning Y Axis Values to the North and South Area Sales Charts

George selected the Dashboard icon from the Charts Ribbon Group, then checked “[Run Chart](#)” for the Chart Type. He clicked on North and South to select them then pressed the “[Build This Dashboard](#)” button.

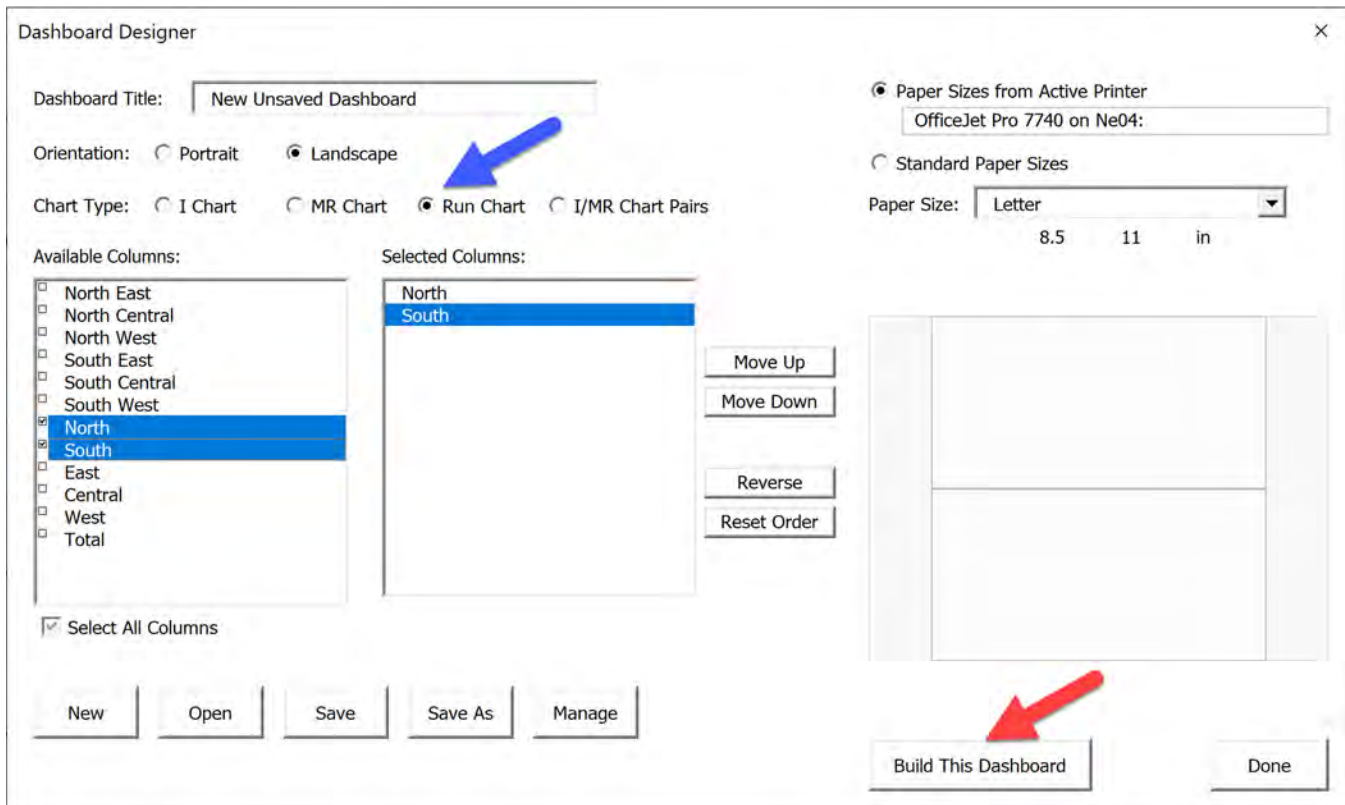


Figure 9.15 Build a Dashboard

The dashboard shows the opposite of What Wesley's score card indicated. While South's sales are lower than North, they are growing while North is declining or at best stabilizing at a lower value.

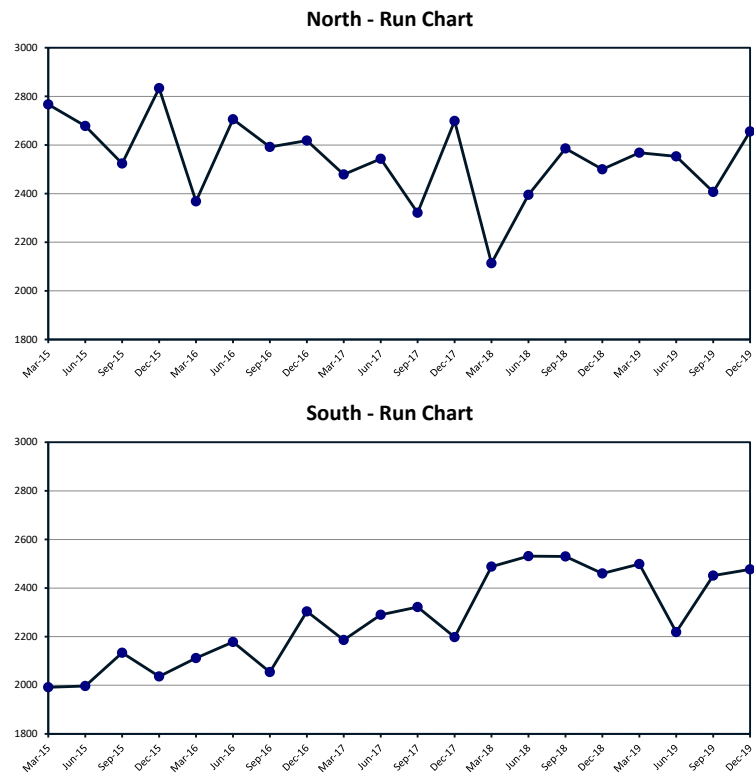


Figure 9.16 Dashboard for North and South.

George next made a dashboard showing the three so called bottom performers, and concluded again that Wesley's approach was harmful.

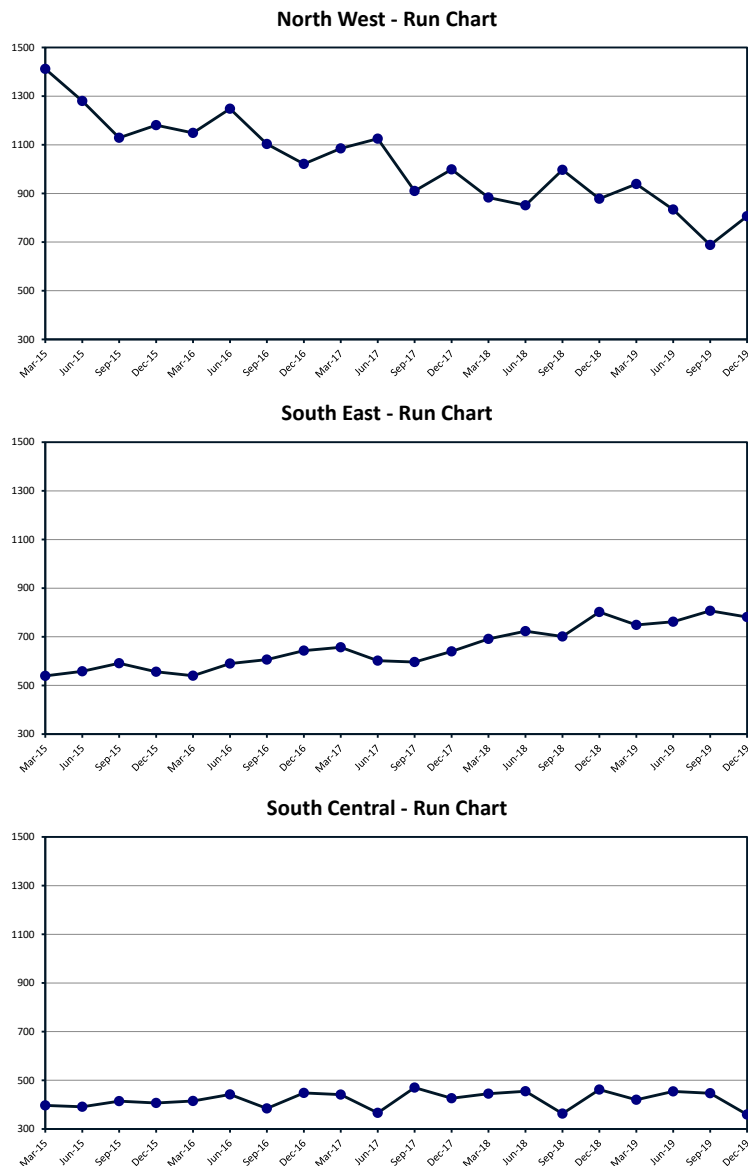


Figure 9.17 Dashboard for So Called Bottom Three Performers

All in all, Wesley's score card approach is totally misleading as were Gail's suggestions about who to fire. Looking at the dashboard for the bottom three, George made these observations, North West was once the highest sales territory but is impacted by the Aerospace manufacturing recession, South East is growing not declining and South Central is a new territory.

He had a lot of discussion to do with the VP's. Wesley had the sales contests set up so that one of the two Executive VPs would win, one of the three regional VP's would win and only one of the Territory Sales Managers would win. To make matters worse the cheating North East Territory Sales Manager won the sales contest every other year.

After discussing the charts separately with each Executive VP, he concluded that they were primarily there to stir up trouble and exacerbate competitiveness amongst the Regional VP's. Pretty much they seemed clueless for the reasons behind the charts. The Regional VP's seemed very much more in touch with their Territory Managers and understood the reasons for the behavior of their results.

George fired the two Executive Vice Presidents, since they were not contributing anything towards team building or sales growth. They were hired purely because they were Wesley's cronies.

George canceled the extravagant sales contest awards. Instead scheduled a three-day sales meeting for all the remaining VP's and their Territory Managers and spouses/guests at a nice golf resort where they spent half the day discussing team building and sales growth ideas. The rest of the day was spent in leisure activities with spouses/guests. Needless to say, they were not surprised to hear that the North East Territory Sales Manager had resigned.

This was the first time in five years that they had all gotten together and had a chance to interact with each other instead of fruitlessly competing against each.

George showed the process behavior charts for each territory and used them to set individual realistic sales goals for each territory. No longer would he abide by the process used by Wesley, an across the board 10% increase for everybody.

The following shows how George used the tools available in PBCharts to both diagnose each territories sales history. He locked in the limits from the most recent predictable time and used that for future monitoring and measurement. Using the information gleaned from the process behavior charts and other market information he set realistic individual sales goals for each territory.

NORTH EAST TERRITORY MODELING

George excluded the data with peaks and valleys where the former territory manager had moved sales from one quarter to the next.

Exclude Points

I Chart

Select values to exclude from calculation of centerline:

Clear Exclusions

<input type="checkbox"/>	Mar-15	924
<input type="checkbox"/>	Jun-15	928
<input type="checkbox"/>	Sep-15	956
<input checked="" type="checkbox"/>	Dec-15	1222
<input checked="" type="checkbox"/>	Mar-16	748
<input type="checkbox"/>	Jun-16	962
<input type="checkbox"/>	Sep-16	983
<input type="checkbox"/>	Dec-16	1024
<input type="checkbox"/>	Mar-17	991
<input type="checkbox"/>	Jun-17	978
<input type="checkbox"/>	Sep-17	1040
<input checked="" type="checkbox"/>	Dec-17	1295
<input checked="" type="checkbox"/>	Mar-18	765
<input type="checkbox"/>	Jun-18	1008
<input type="checkbox"/>	Sep-18	1038
<input type="checkbox"/>	Dec-18	952
<input type="checkbox"/>	Mar-19	1041
<input type="checkbox"/>	Jun-19	1020
<input type="checkbox"/>	Sep-19	976
<input checked="" type="checkbox"/>	Dec-19	1148

Apply Changes

Undo Changes

Moving Range Chart

Select values to exclude from calculation of limits:

Clear Exclusions

<input type="checkbox"/>	Mar-15	
<input type="checkbox"/>	Jun-15	4.0
<input type="checkbox"/>	Sep-15	28.0
<input type="checkbox"/>	Dec-15	266.0
<input type="checkbox"/>	Mar-16	474.0
<input type="checkbox"/>	Jun-16	214.0
<input type="checkbox"/>	Sep-16	21.0
<input type="checkbox"/>	Dec-16	41.0
<input type="checkbox"/>	Mar-17	33.0
<input type="checkbox"/>	Jun-17	13.0
<input type="checkbox"/>	Sep-17	62.0
<input type="checkbox"/>	Dec-17	255.0
<input type="checkbox"/>	Mar-18	530.0
<input type="checkbox"/>	Jun-18	243.0
<input type="checkbox"/>	Sep-18	30.0
<input type="checkbox"/>	Dec-18	86.0
<input type="checkbox"/>	Mar-19	89.0
<input type="checkbox"/>	Jun-19	21.0
<input type="checkbox"/>	Sep-19	44.0
<input type="checkbox"/>	Dec-19	172.0

Apply Changes

Undo Changes

☒ Show Excluded Points (Red "X" Marker)

☐ Hide Excluded Points

Apply All Changes

Undo All Changes

Done

Figure 9.18 Exclude Peak and Valley Data

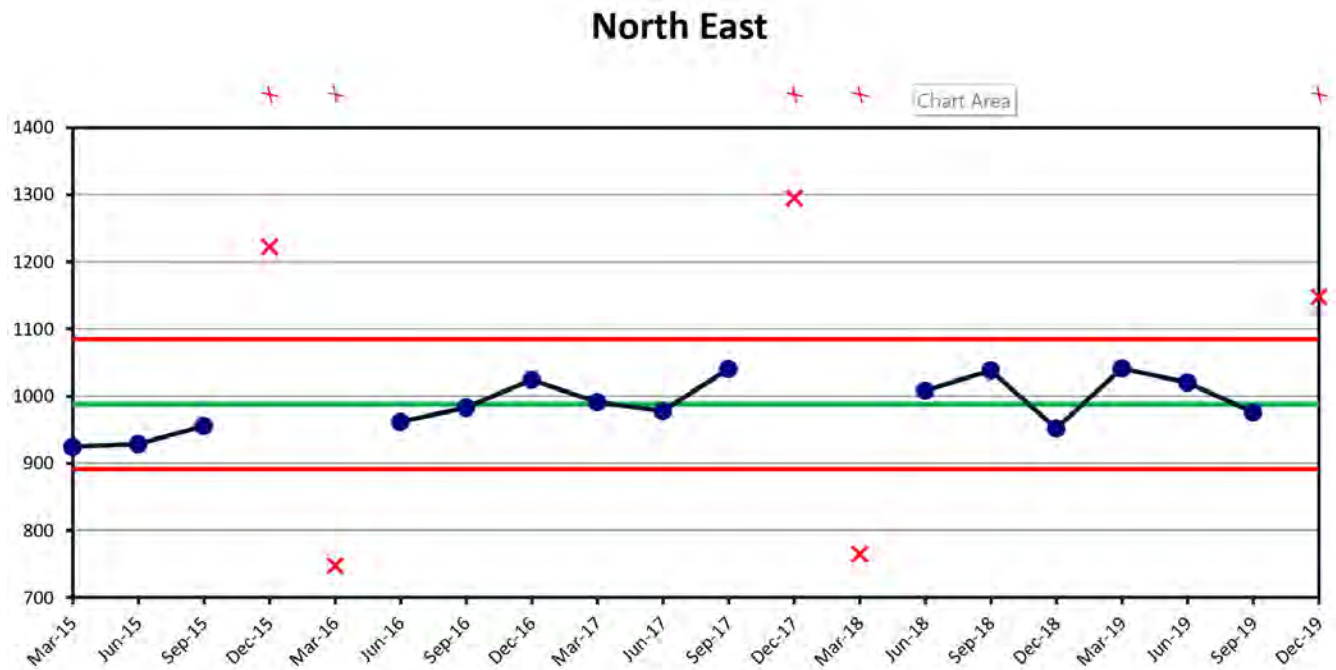


Figure 9.19 Excluded Peaks and Valleys

Next George selected to view the data from June-16 to Sep-19, the most recent data that appears stable.

Select X Axis Display Range ✕

Define X axis range to display in your charts
(unseen points may still be included in calculations)

☐ Display Complete Data Range
☐ Display Last Points
☒ Display Partial Data Range (define below)

Starting Point

Ending Point

Figure 9.20 Viewing the most recent stable data

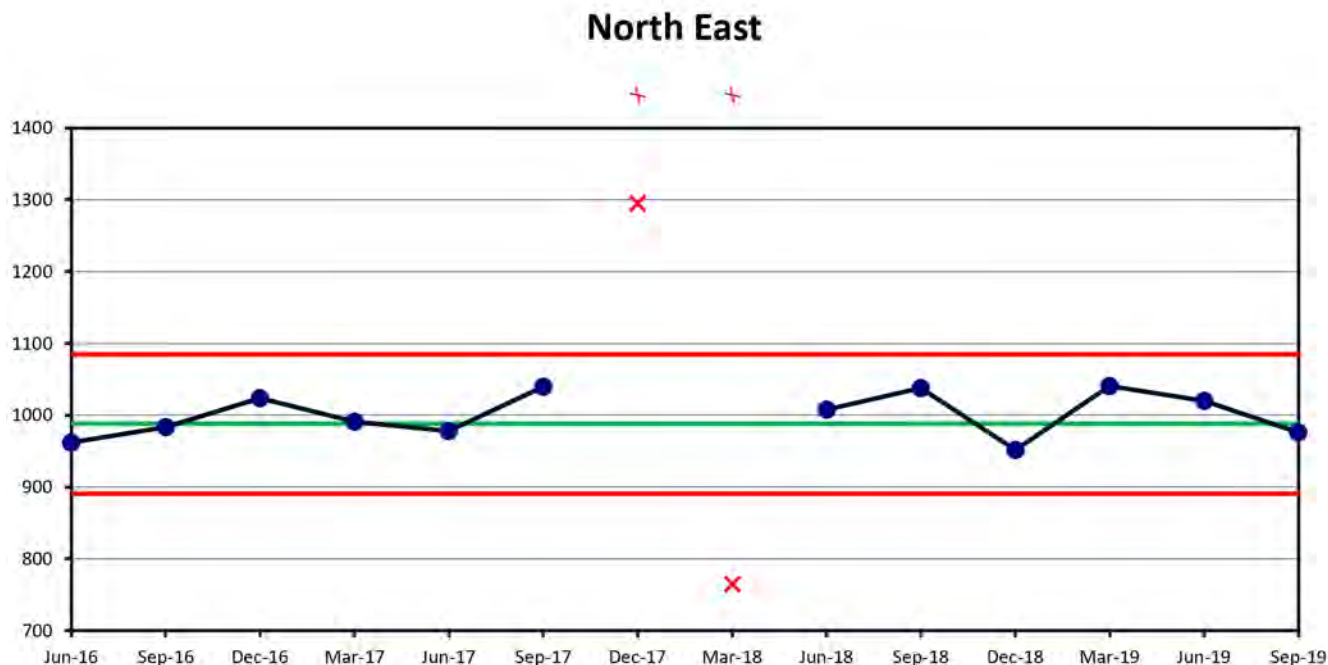
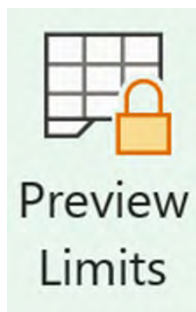


Figure 9.21 Jun-16 to Sep-19 Data



George next locked the natural process Limits for this data pressing the Preview Limits button. When the Preview Lock Limits dialog appeared he selected “[Treat visible range as a new range ...](#)”

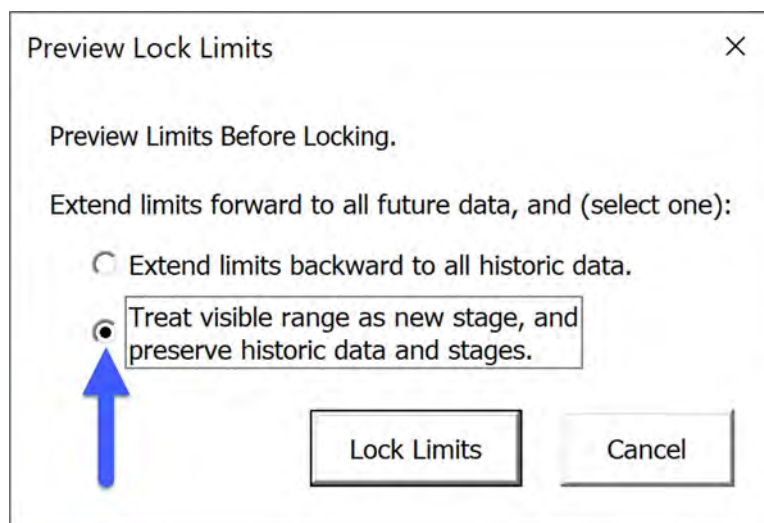


Figure 9.22 Locking Limits

Next, he selected to view all the data with newly locked Limits in place.

Select X Axis Display Range

Define X axis range to display in your charts
(unseen points may still be included in calculations)

☒ Display Complete Data Range

☐ Display Last 25 Points

☐ Display Partial Data Range (define below)

Starting Point
Jun-16

Ending Point
Sep-19

OK Cancel

Figure 9.23 View All Data

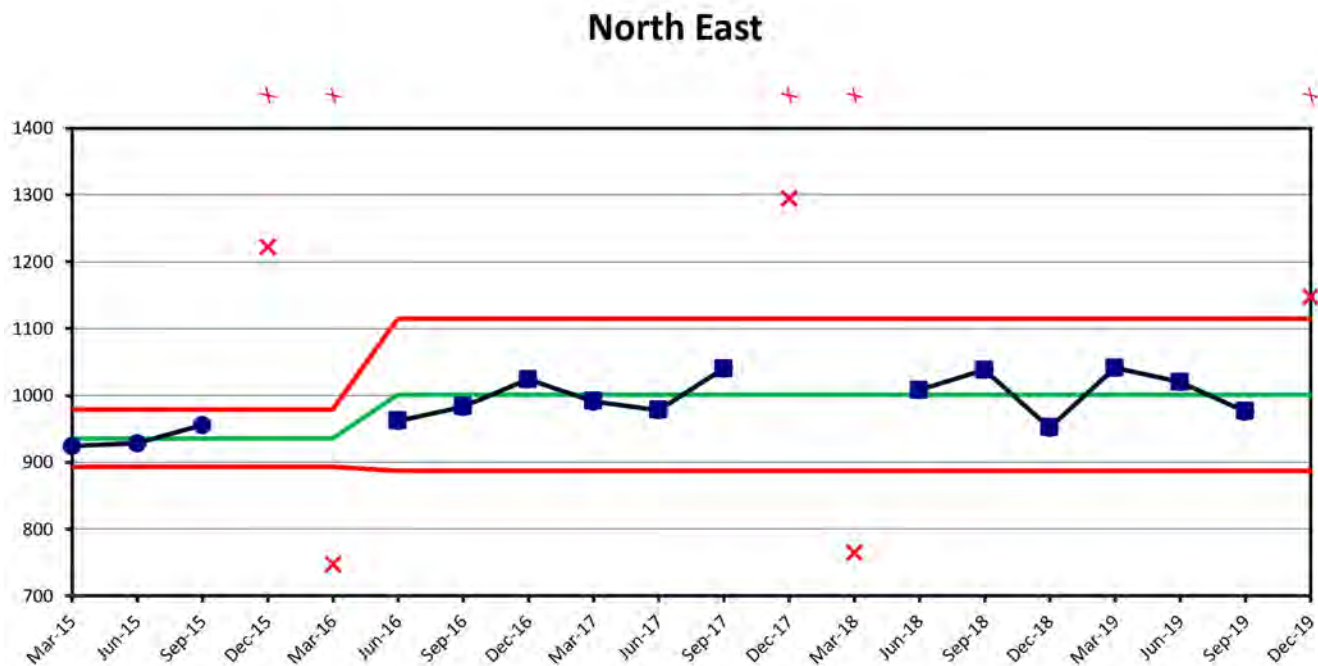


Figure 9.24 Locked Limits

Considering the economy in the North East region and where they had been, George gave a 3% increase in Sales as a target for next year which coincided with the expected North East expected inflation rate. The centerline value is 1001.1 times 1.03 give the 2020 target of 1031 rounded to 1030.

Target
×

Enter a target value for this I chart.

☐ Apply this target value to all I charts.

Figure 9.25 Setting a Target for North East.

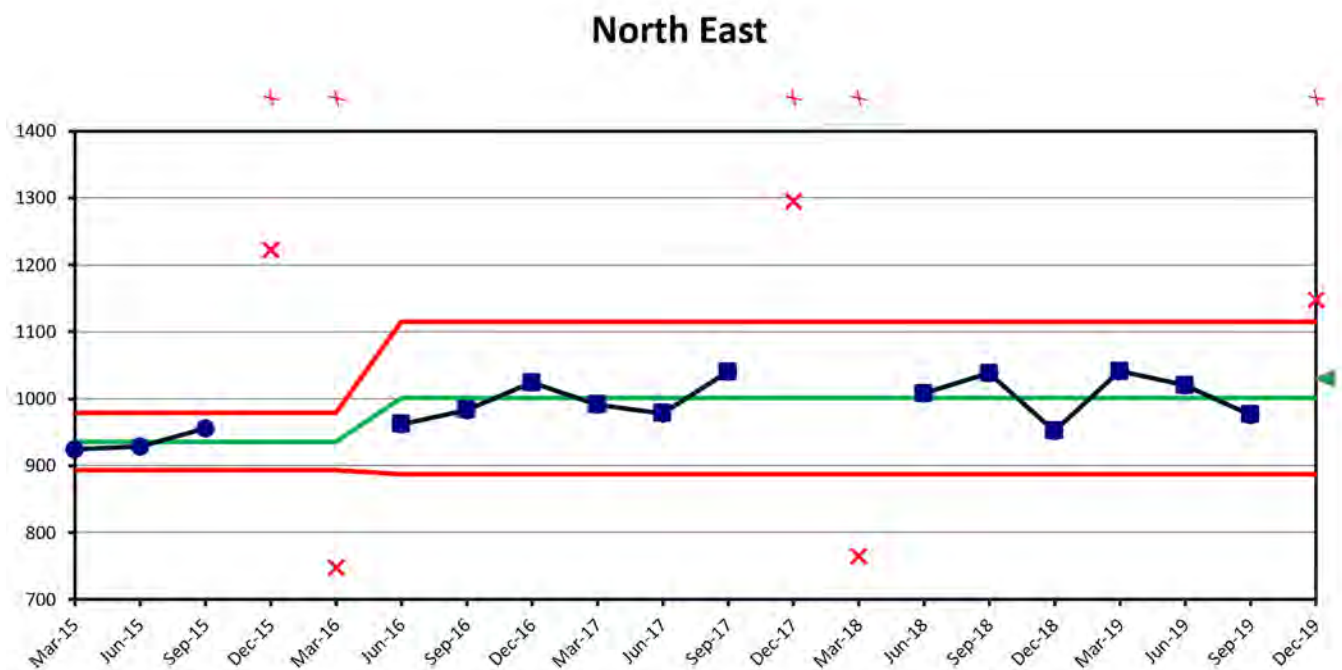


Figure 9.26 Goal for North East for 2020

NORTH CENTRAL TERRITORY MODELING

George modeled the North Central territory with stages and a linear trend starting in Sep-17.

Manage Staged Analysis

Select points where each new stage begins (first point is always selected):

<input checked="" type="checkbox"/>	Mar-15	431.0
<input type="checkbox"/>	Jun-15	470.0
<input type="checkbox"/>	Sep-15	439.0
<input type="checkbox"/>	Dec-15	431.0
<input type="checkbox"/>	Mar-16	471.0
<input type="checkbox"/>	Jun-16	496.0
<input type="checkbox"/>	Sep-16	506.0
<input type="checkbox"/>	Dec-16	573.0
<input type="checkbox"/>	Mar-17	403.0
<input type="checkbox"/>	Jun-17	440.0
<input checked="" type="checkbox"/>	Sep-17	371.0
<input type="checkbox"/>	Dec-17	405.0
<input type="checkbox"/>	Mar-18	466.0
<input type="checkbox"/>	Jun-18	536.0
<input type="checkbox"/>	Sep-18	551.0
<input type="checkbox"/>	Dec-18	670.0
<input type="checkbox"/>	Mar-19	588.0
<input type="checkbox"/>	Jun-19	699.0
<input type="checkbox"/>	Sep-19	743.0
<input type="checkbox"/>	Dec-19	702.0

Calculation of Limits

☒ Calculate Separate Limits for Each Stage

☐ Calculate Combined Limits for All Stages

Define Trends for Each Stage

Clear Stages

OK Cancel

Manage Trends

Stage Start	Stage Trend
Mar-15	No Trend
Sep-17	Linear

Define trend for selected stage

☐ No Trend

☒ Linear

☐ Exponential

Redefine Stages

OK Cancel

Figure 9.27 Creating Two Stages with One Trend

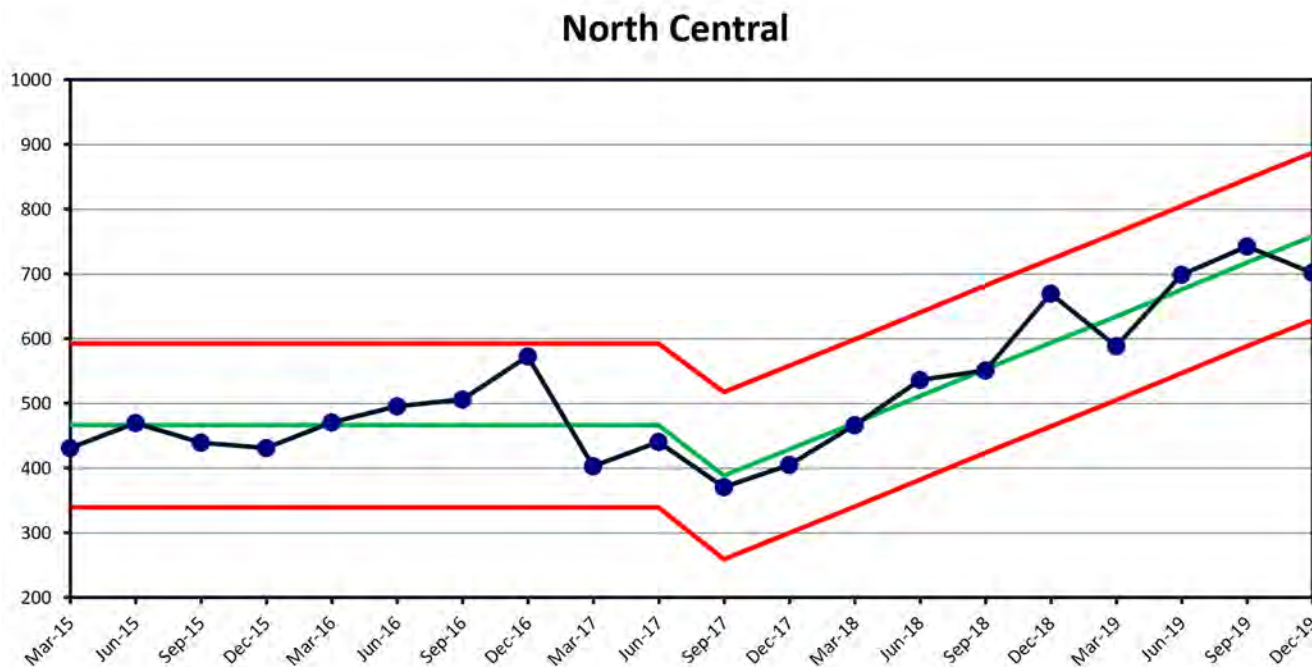


Figure 9.28 Trend Starting Sep-17

Next locked the limits starting with the trend at Sep-17.

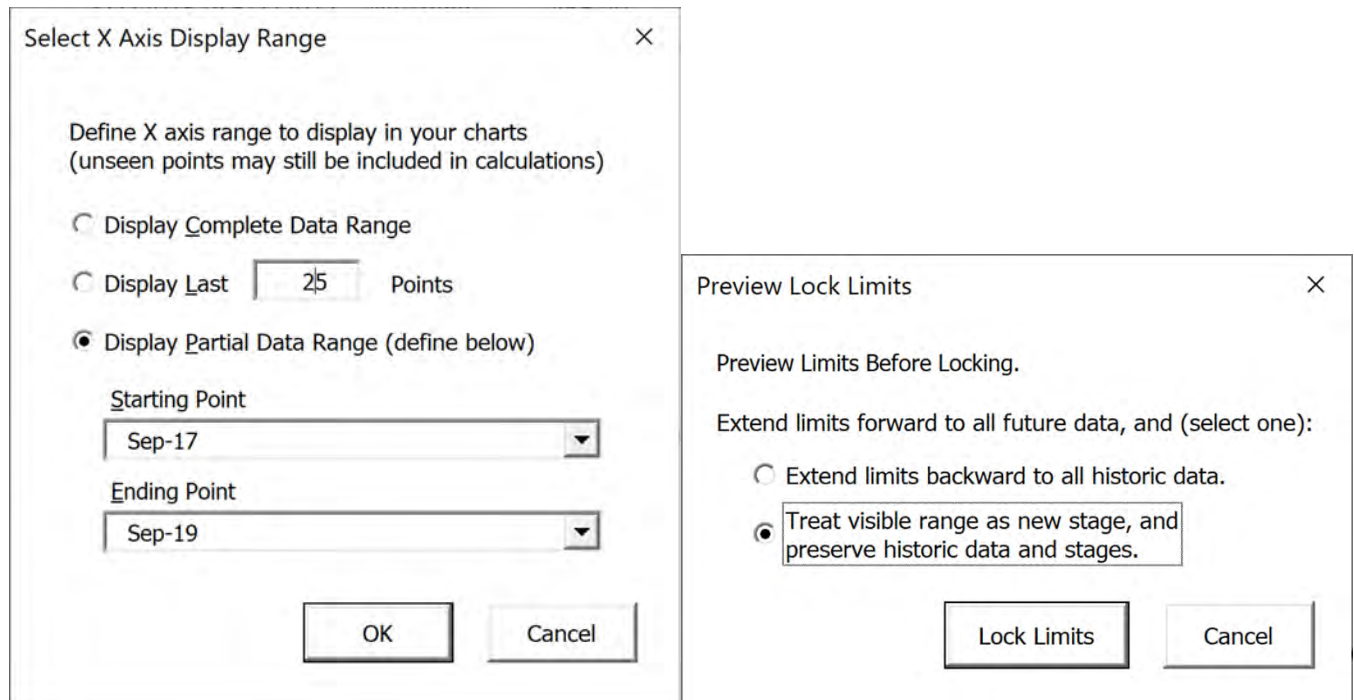


Figure 9.29 Locking Limits to Trend

To set a goal, George extended the date column to Dec-20 in the Data tab, and pulled off the value of the centerline at Dec-20, 971.82 rounded to 972 and used that as the goal, see Figure 9.30.

Quarter	North East	North
		Central
Sep-19	976	743
Dec-19	1148	702
Mar-20		
Jun-20		
Sep-20		
Dec-20		

Figure 9.29 Extending the Time Axis

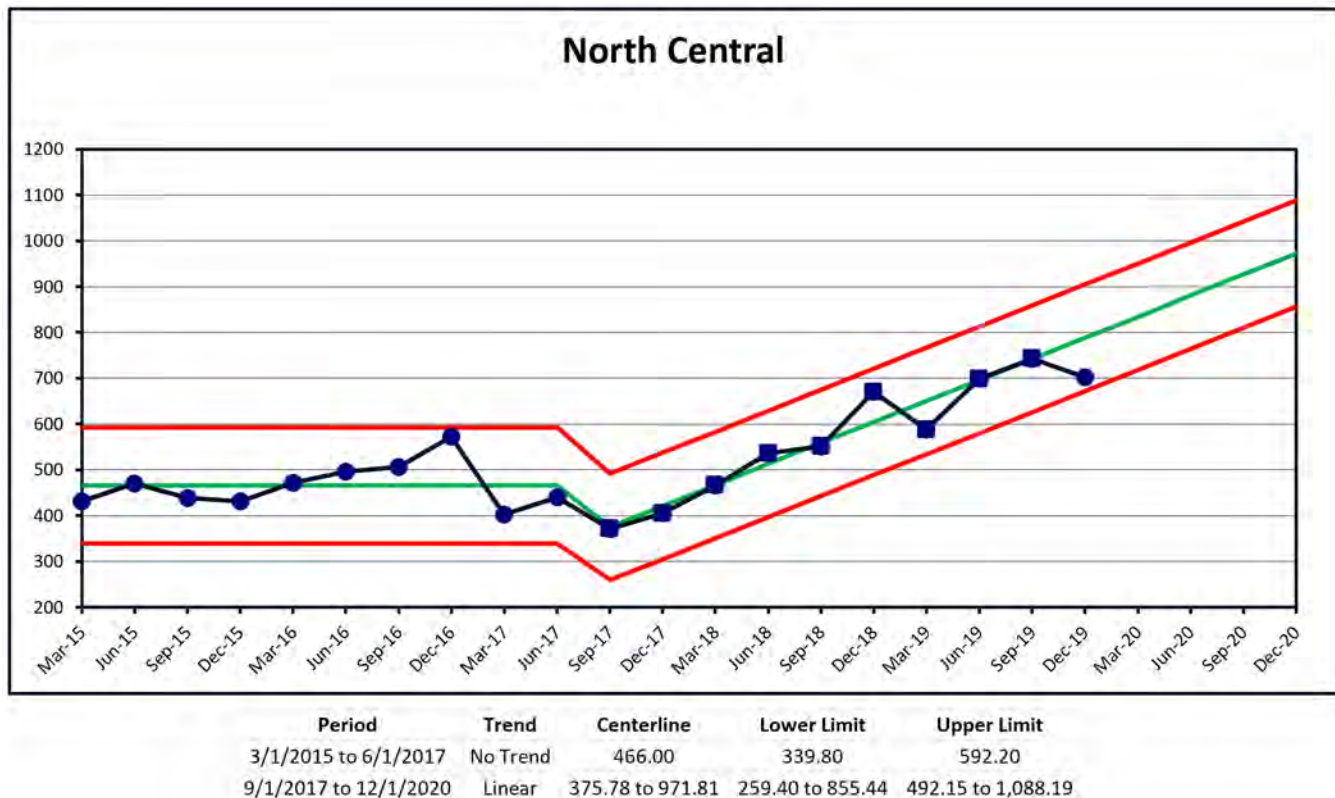


Figure 9.30 Center Line Value at Dec-20 is 971.81

Target ×

Enter a target value for this I chart.

☐ Apply this target value to all I charts.

Figure 9.31 Setting Goals for North Central for Dec-20

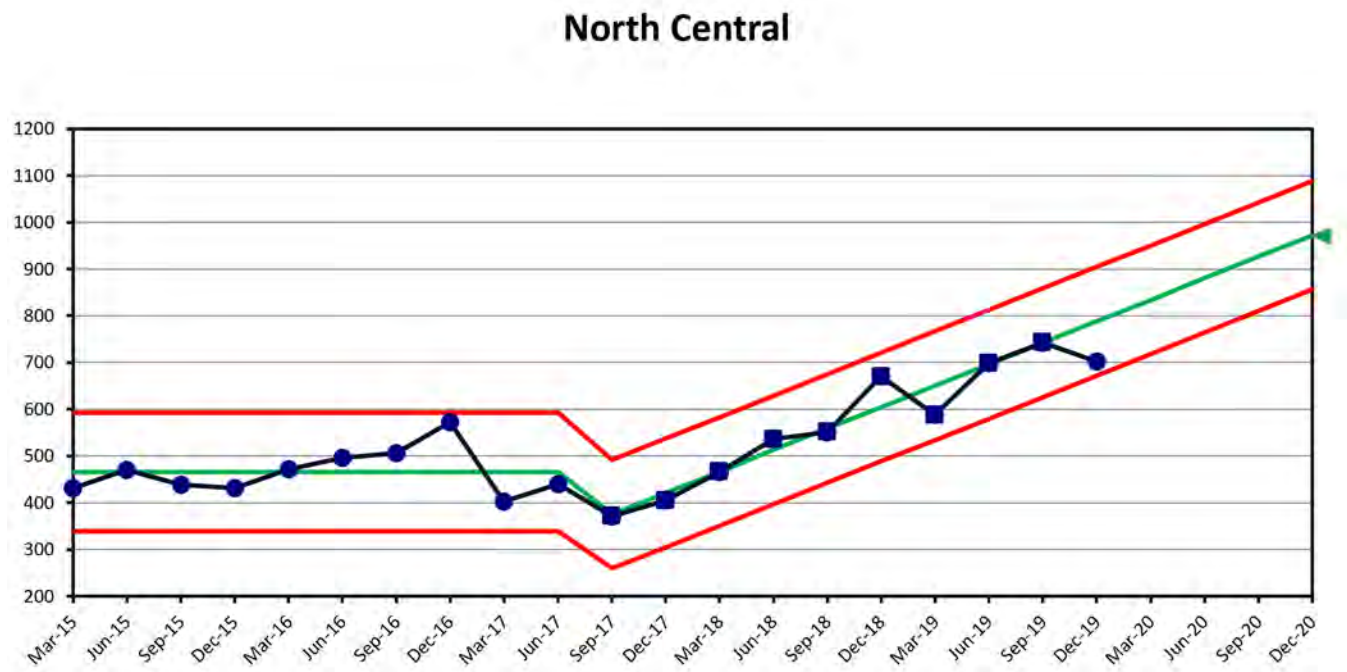


Figure 9.32 Goal for North Central for 2020

NORTH WEST TERRITORY MODELING

You are now familiar with setting stages, and locking limits so I'll just describe how George modeled the data.

George added an artificial no trend stage starting at Mar-19 to estimate the average quarterly sales for 2019. The stage from Mar-15 through Dec-18 was modeled with a liner Trend.

George locked the limits based on the Mar-19 to Dec-19 data and used the centerline average, 816.8 as the average for year 2019 as a basis for setting goal for 2020. He again used the 3% inflation estimate to set the goal at 840.

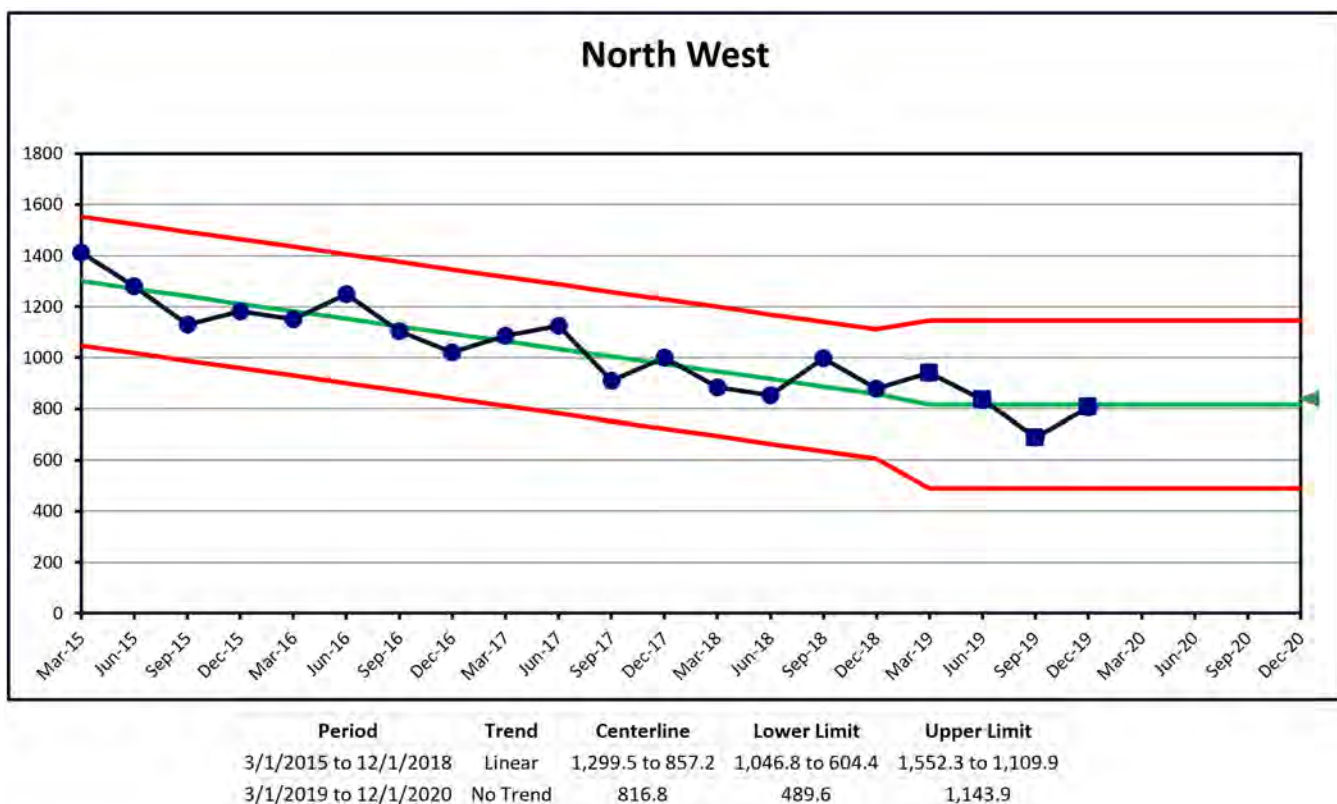


Figure 9.33 Goal for North West for 2020

SOUTH EAST TERRITORY MODELING

George modeled all the data as a trend, used all the data to lock limits. Used 850 as the rounded value of the centerline at Dec-20 as the goal for 2020 an almost 9% increase for 2020.

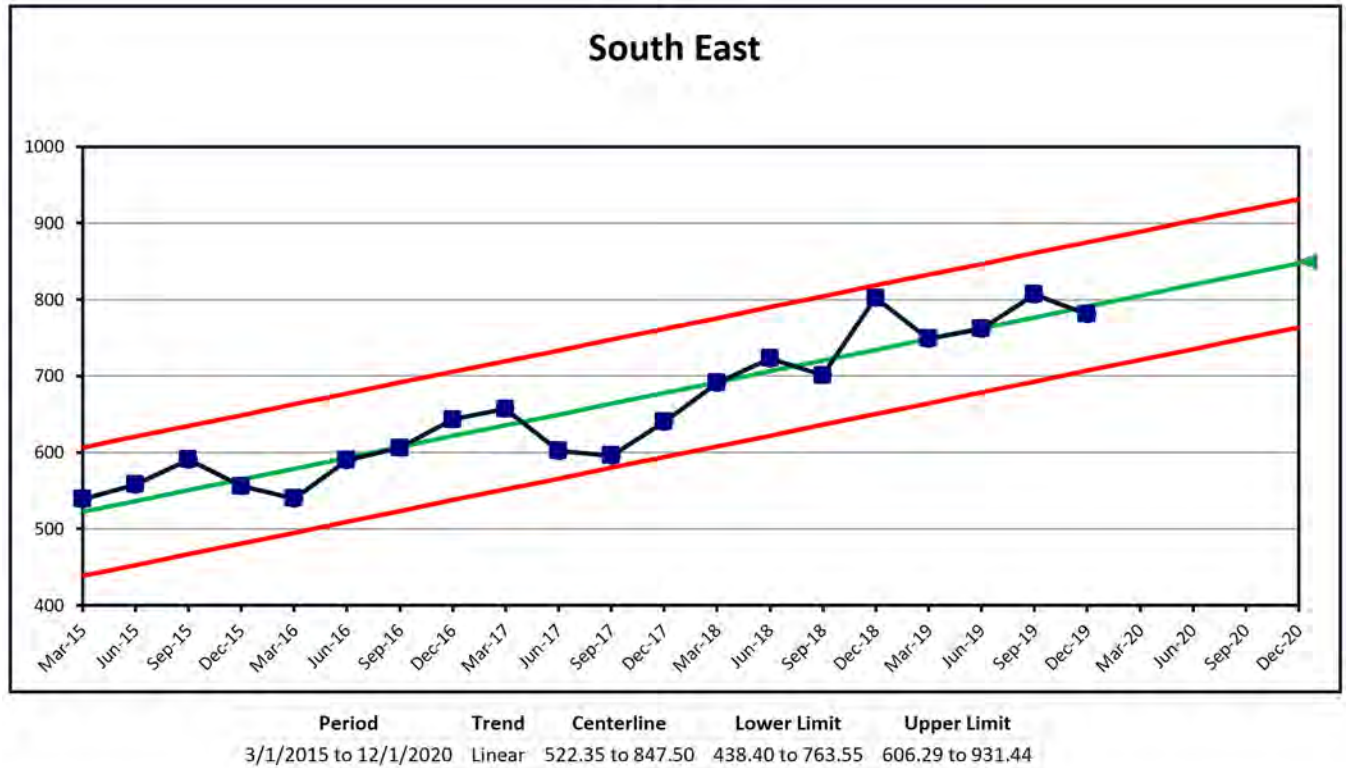


Figure 9.34 Goal for South East for 2020

SOUTH CENTRAL TERRITORY MODELING

George locked the limits based on all the data as is, no trend. Set the 2020 goal 3% higher using the average inflation number again.

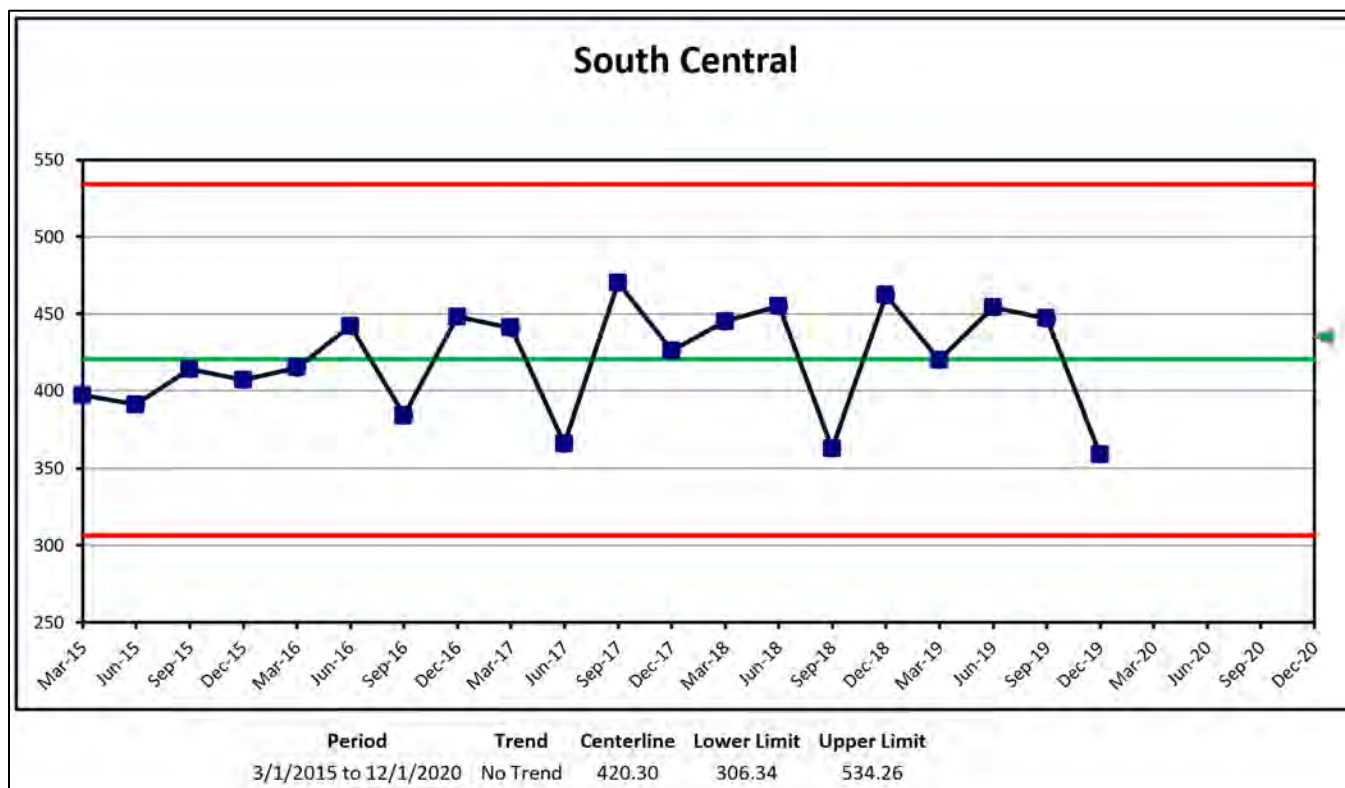


Figure 9.35 Goal for South Central for 2020

SOUTH WEST TERRITORY MODELING

George started a no trend stage at Dec-18, the previous stage modeled as a trend. George locked the limits using the Dec-18 to Dec-19 data then set the goal at 1270 almost 5% higher than the baseline value of 1212.6. George expected more than the 3% growth from the South west as it had been growing at 7.5% per year from Mar-15 through Sep-18.

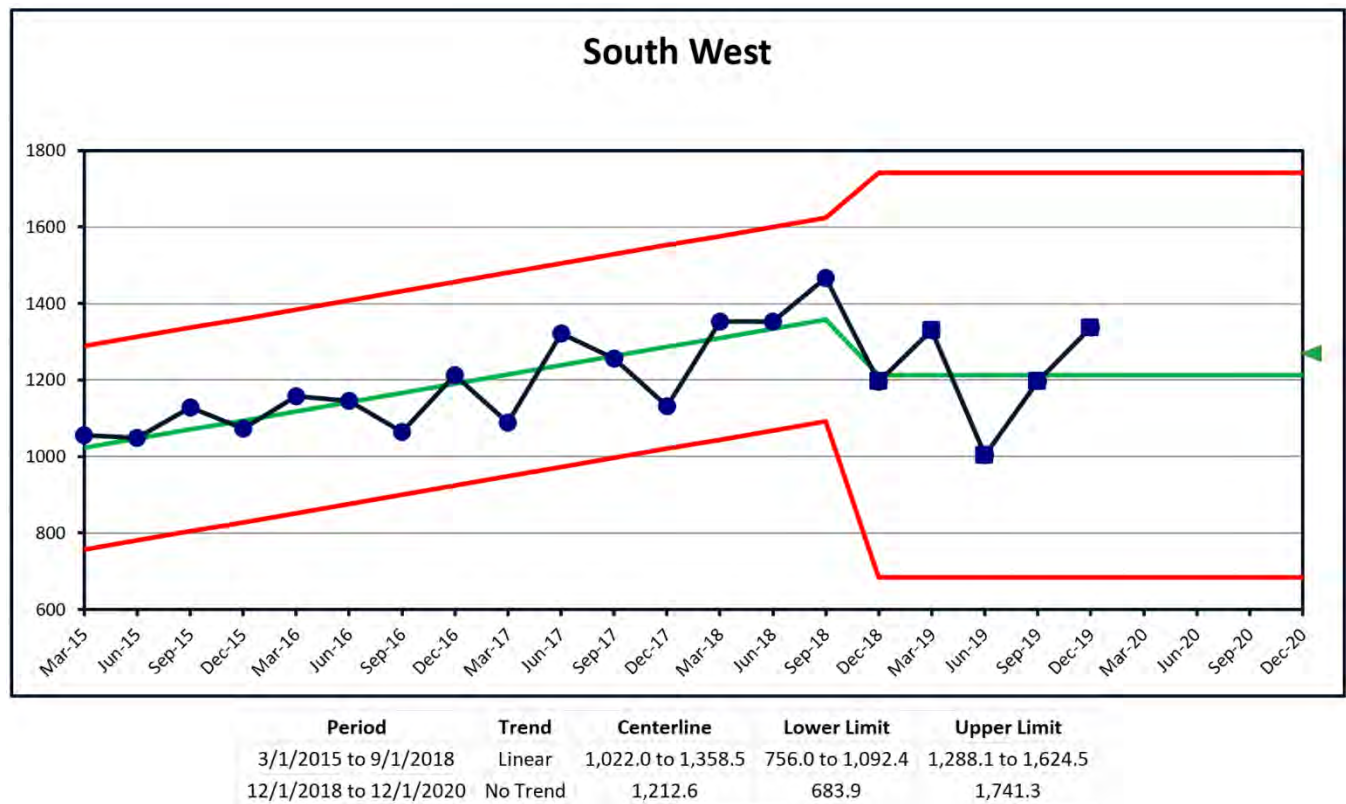


Figure 9.36 Goal for South West for 2020

DASHBOARD FOR ALL TERRITORIES FOR 2020

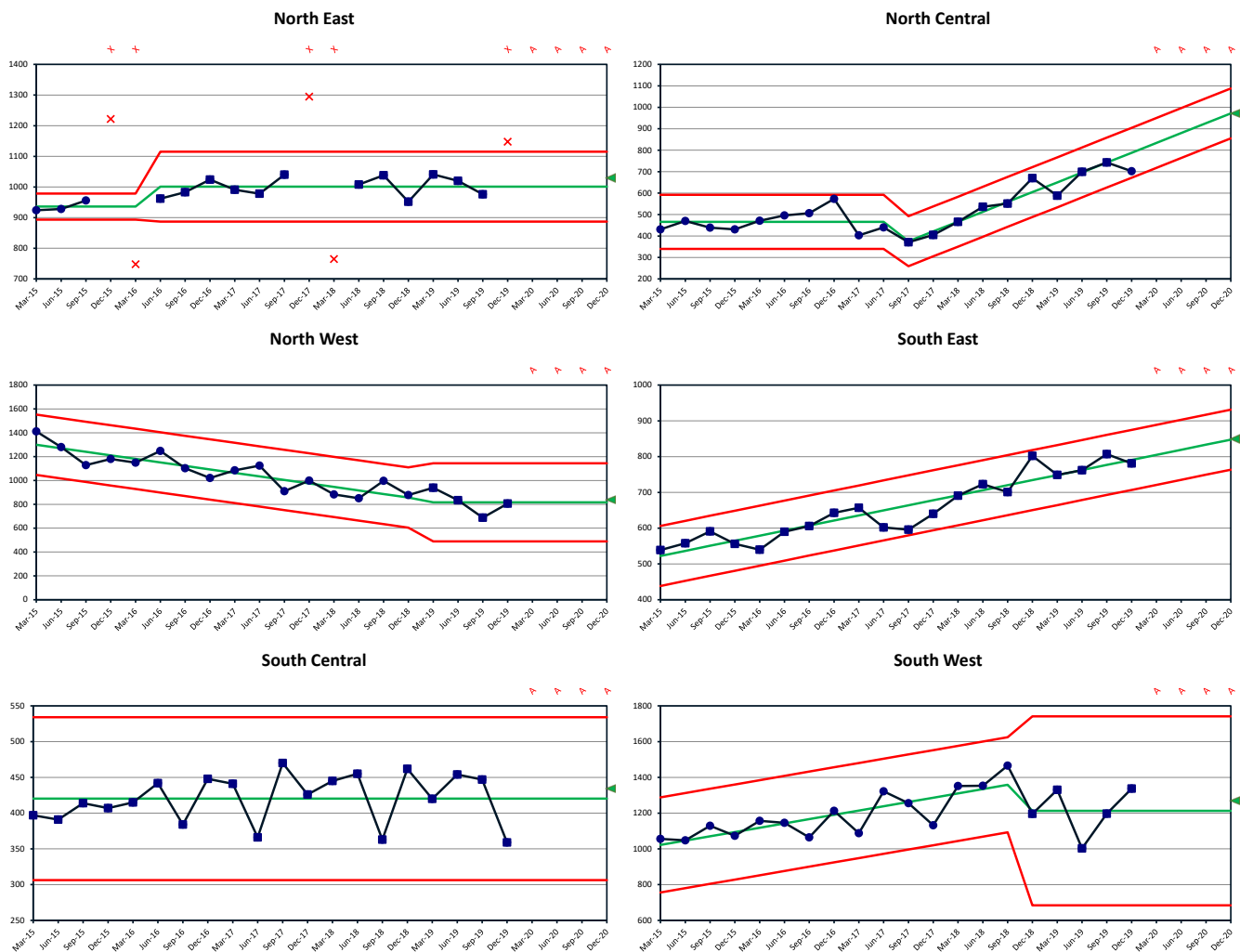


Figure 9.37 Dashboard Goals for 2020

DASHBOARD FOR EAST, CENTRAL AND WEST

The goal setting for North and South Areas is no longer a priority because the Executive Vice Presidents have been sent back to their venture capital firms.

However the three Vice Presidents for East, Central and West Region have goals from each of their two territories. The goal for each Region is the sum of the individual goals for each territory.

Modeling and setting is displayed in the Dashboard below.

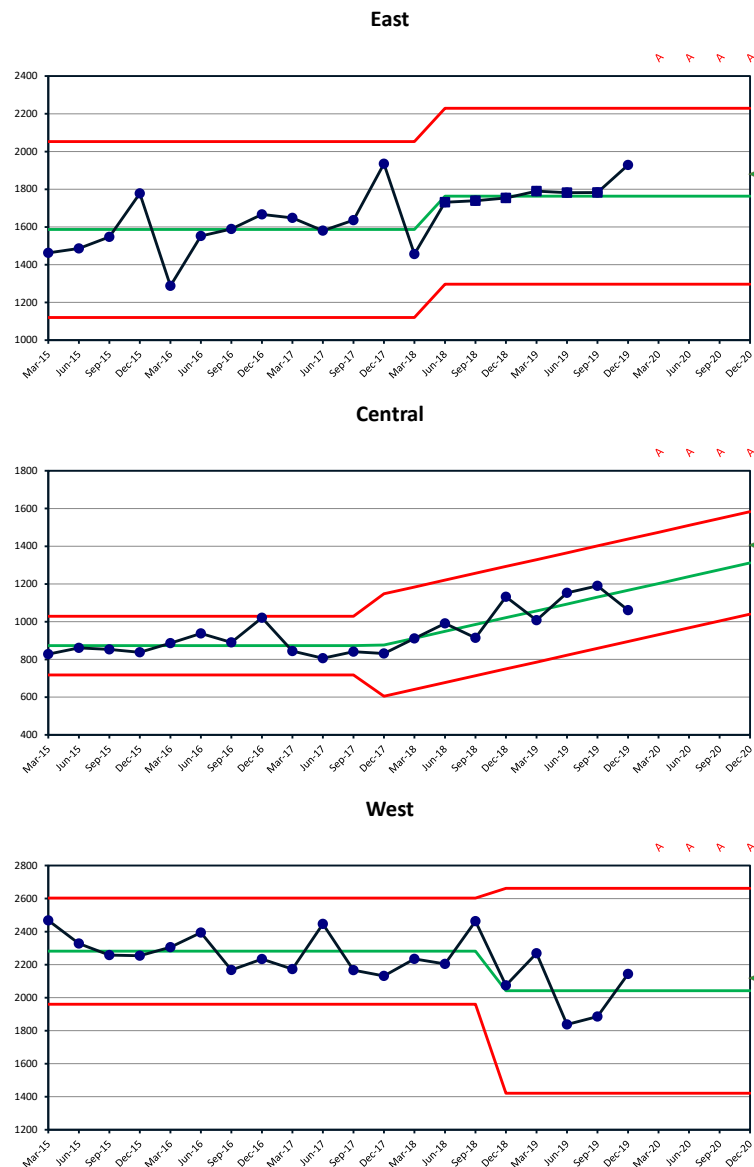


Figure 9.38 Goals for East, Central and West Regions.

At the end of the year George had saved over a half a million dollars in sales expenses reducing expenses by 20%. He canceled the extravagant reward trips and eliminated a layer of middle management. The Territory Managers were performing better and the Regional VP's were cooperating instead of competing to grow sales. The annual sales meeting was a great success for all attendees. George was proud to announce that sales increased 6%, twice the annual rate of inflation and said they were on track for a 10% increase .

Not a bad accomplishment for his first year!

Chapter 10

WHEELER SOFTWARE VERIFICATION DATA

COMPARISON

Donald Wheeler's massive output of Control Chart documentation⁶ provides formulas for the centerlines, upper and lower limits. He generally advocates for hand computation.

One of the big benefits of the PBCharts is it removes the burden of remembering formulas and manually computing values. Wheeler has expressed concern about software and has issued the following warning.

"Since most software packages contain options that compute limits incorrectly you should verify the computations in your software. To determine which option in a software package computes the limits for an X Chart correctly you may use the software with the verification data set on the preceding page." (Wheeler, 2010)

The data from page 254 is reproduced below with permission from Donald Wheeler.

Verification Table for Individual Values: 16 Resistances in Megohms from Table 2.4

	X	mR		X	mR		X	mR		X	mR
-1-	5045		- 5-	4290	315	-9-	3980	305	-13-	3300	460
-2-	4350	695	-6-	4430	140	-10-	3925	55	-14-	3685	385
-3-	4350	0	-7-	4485	55	-11-	3645	280	-15-	3463	222
-4-	3975	375	-8-	4285	200	-12-	3760	115	-16-	5200	1737

Figure 10.1 Verification Data Set

⁶ Reducing Production Costs, Donald J. Wheeler, ©2010, SPCPress.com, Knoxville TN.

As Wheeler wrote on page 255 of *Reducing Production Costs*:

“Using the average of 4135.50 and the average moving range of 355.93 the correct limits are:

$$LNPL = 3188.72, UNPL = 5082.28, \text{ and } URL = 1163.19.$$

Or, using the median moving range of 280, the correct limits are:

$$LNPL = 3254.90, UNPL = 5016.10, \text{ and } URL = 1082.20.$$

If an option in a software package is used to compute limits for Individual Values using the 16 values from the verification data set, and if those limits do not agree with one of the [...] sets of limits given above, then that option is incorrect and should not be used in practice.”

The data appears as follows in the data worksheet of the PBCharts add-in.

The screenshot shows the PBCharts add-in interface. The 'Data' tab is selected, displaying a worksheet with 16 rows of data. The first column is labeled 'Index' and the second column is labeled 'Resistance (Megaohms)'. The data values are as follows:

Index	Resistance (Megaohms)
1	5045
2	4350
3	4350
4	3975
5	4290
6	4430
7	4485
8	4285
9	3980
10	3925
11	3645
12	3760
13	3300
14	3685
15	3463
16	5200

The interface includes a ribbon with tabs: File, Home, Insert, Page Layout, Formulas, Data, Review, View, Developer, Add-ins, Help, Acrobat, PBCharts, and Peltier 1. The PBCharts ribbon contains buttons for Open, Import Data, Analyze Selected, Blank, Save, Save As, Select Column, Analysis, Charts, and Other Settings. The status bar at the bottom shows 'Ready', 'Calculate', 'Display Settings', and a zoom level of 100%.

Figure 10.2 Wheeler Verification Data in PBCharts

PBCharts I Chart where the limits are calculated from the Average Moving Range.

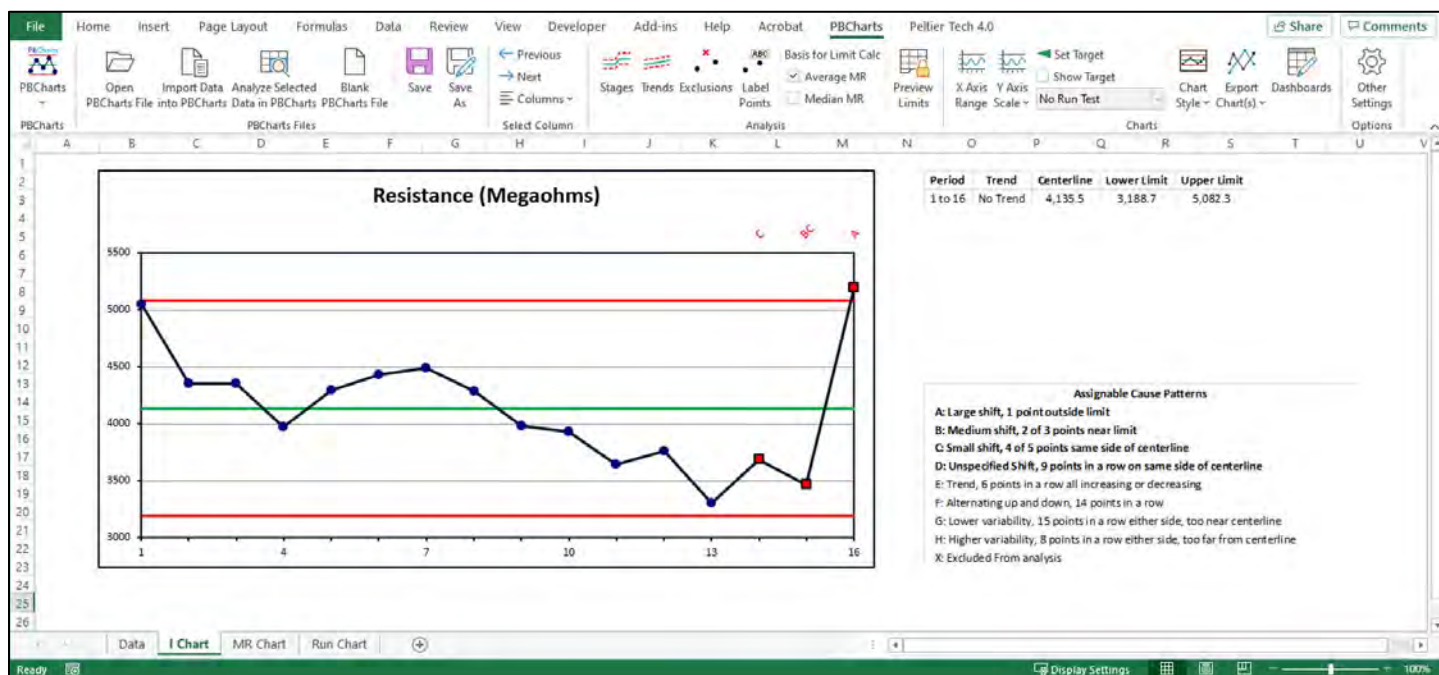


Figure 10.3 I Chart using Average Moving Range

PBCharts Moving Range Chart where the limits are calculated from the Average Moving Range.

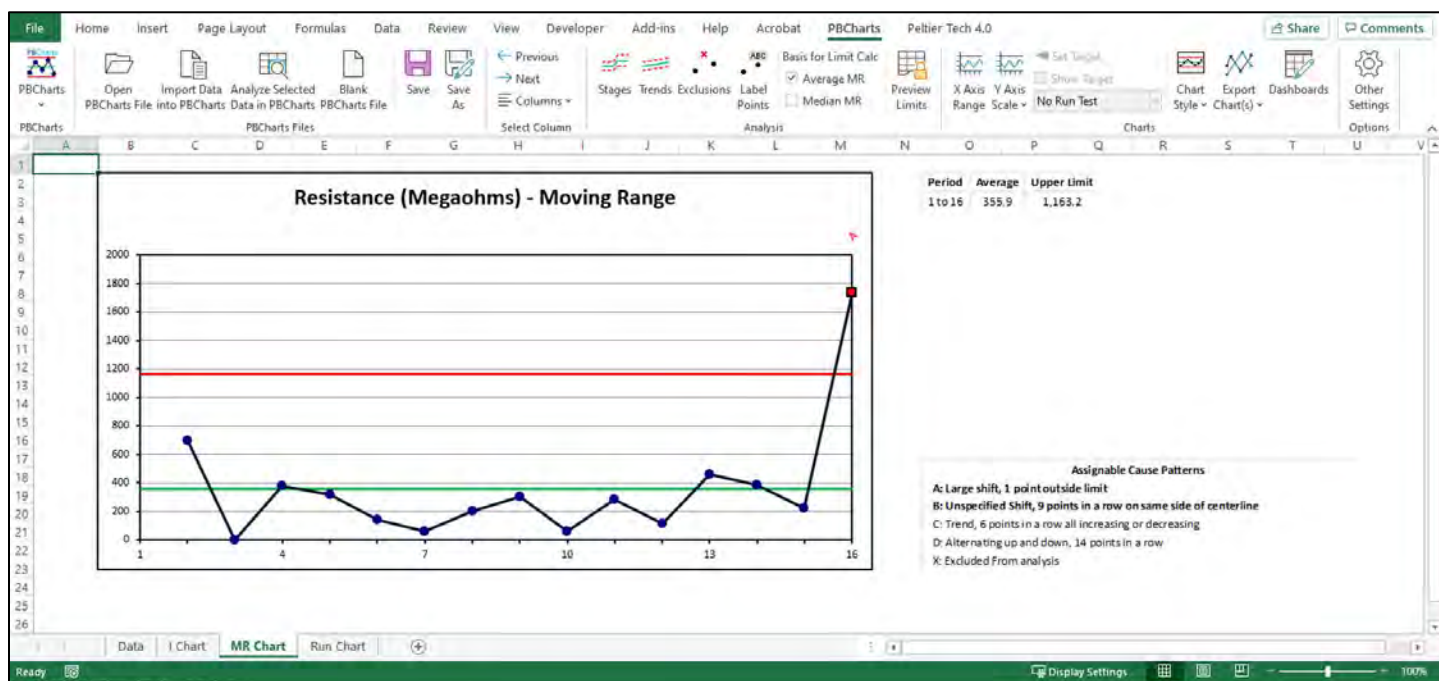


Figure 10.4 MR Chart using Average Moving Range

PBCharts I Chart where the limits are calculated from the Median Moving Range.

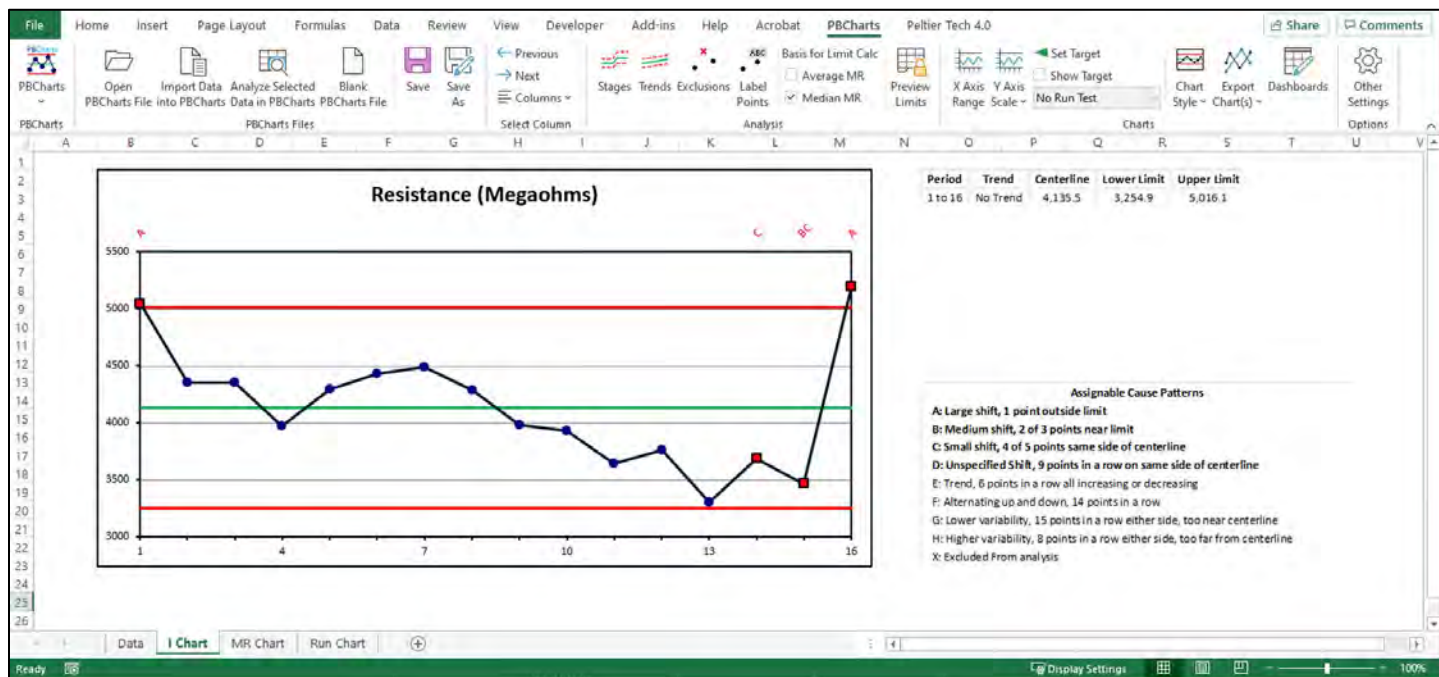


Figure 10.5 I Chart using Median Moving Range

PBCharts Moving Range Chart where the limits are calculated from the Median Moving Range

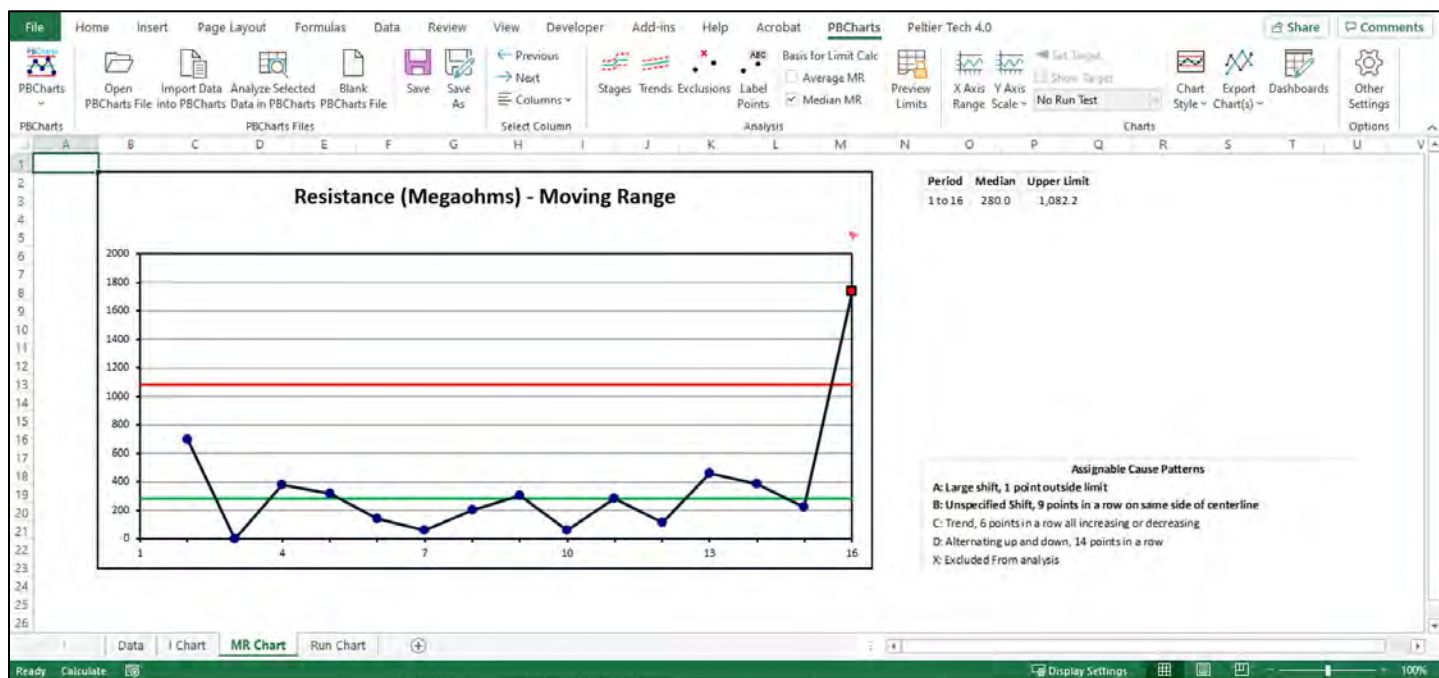
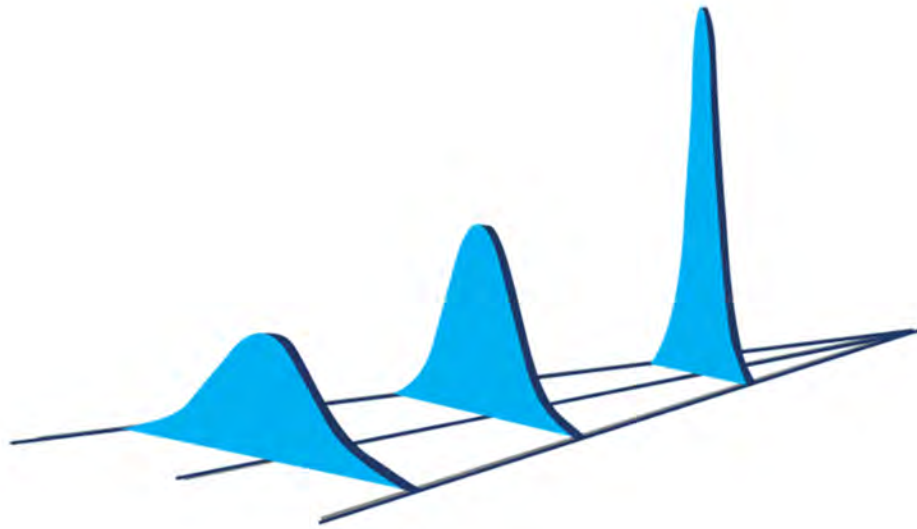


Figure 10.6 MR Chart using Median Moving Range

Here is the summary of the comparisons, where the PBCharts values equal Wheelers results when Wheeler's data is rounded to one digit.

Estimator		PBCharts	Wheeler
Average Moving Range	Centerline I Chart	4135.5	4135.5
	Lower Limit I Chart	3188.7	3188.72
	Upper Limit I Chart	5082.3	5082.28
	Average Moving Range	355.9	355.93
	Upper Limit Range Chart	1163.2	1163.19
Median Moving Range	Centerline I Chart	4135.5	4135.5
	Lower Limit I Chart	3254.9	3254.9
	Upper Limit I Chart	5016.1	5016.1
	Median Moving Range	280.0	280.0
	Upper Limit Range Chart	1082.2	1082.2

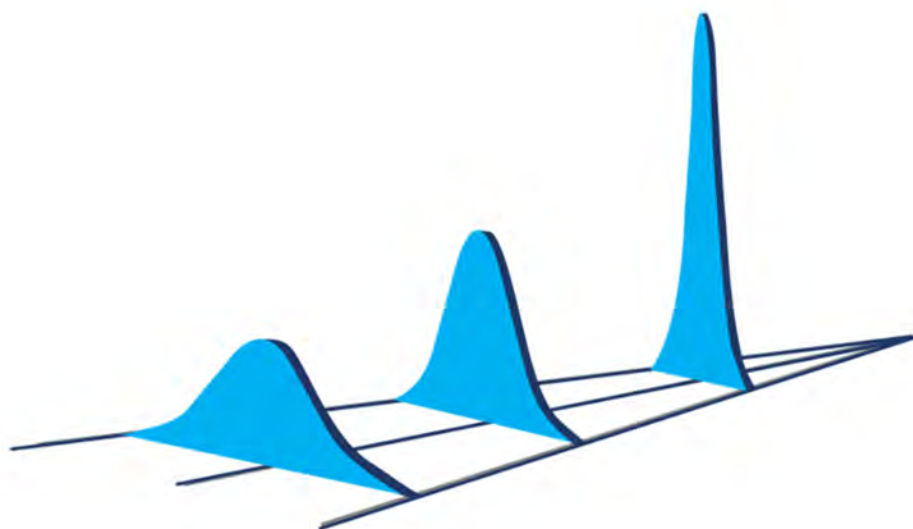
Figure 10.7 Validation table



REFERENCES

Wheeler, D. J. (2000). *Understanding Variation the Key to Managing Chaos* (2nd ed.). Knoxville, Tennessee, USA: SPC Press. Retrieved from https://spcpress.com/book_understanding_variation.php

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