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# STATISTICAL ANALYSIS WITH EXCEL

	s1	s2
Mean	7.3202	7.2345
Variance	32.6754	40.1309
Observations	168	168
Df	167	167
	0.8142	
P (F<= f) one-tail	0.0926	
F Critical one-tail	0.8747	

**z-Test: Two Sample for Means**

Input

Variable 1 Range:

Variable 2 Range:

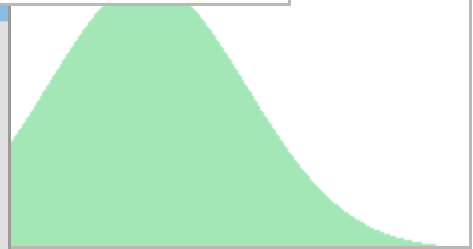
Hypothesized Mean Difference:

Variable 1 Variance (known):

Variable 2 Variance (known):

Labels

Alpha:



# Statistical Analysis With Excel

Volume 5 in the series **Excel for Professionals**

Volume 1: Excel For Beginners

Volume 2: Charting in Excel

Volume 3: Excel-- Beyond The Basics

Volume 4: Managing & Tabulating Data in Excel

Volume 5: Statistical Analysis with Excel

Volume 6: Financial Analysis using Excel

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**Publisher:** VJ Books Inc, Canada

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## ABOUT THE AUTHOR

Vijay Gupta has taught statistic, econometrics, and finance to institutions in the US and abroad, specializing in teaching technical material to professionals.

He has organized and held training workshops in the Middle East, Africa, India, and the US. The clients include government agencies, financial regulatory bodies, non-profit and private sector companies.

A Georgetown University graduate with a Masters degree in economics, he has a vision of making the tools of econometrics and statistics easily accessible to professionals and graduate students. His books on SPSS and Regression Analysis have received rave reviews for making statistics and SPSS so easy and “non-mathematical.” The books are in use by over 150,000 users in more than 140 nations.

He is a member of the American Statistics Association and the Society for Risk Analysis.

In addition, he has assisted the World Bank and other organizations with econometric analysis, survey design, design of international investments, cost-benefit, and sensitivity analysis, development of risk management strategies, database development, information system design and implementation, and training and troubleshooting in several areas.

Vijay has worked on capital markets, labor policy design, oil research, trade, currency markets, and other topics.

# VISION

Vijay has a vision for software tools for Office Productivity and Statistics. The current book is one of the first tools in stage one of his vision. We now list the stages in his vision.

## **Stage one:** Books to *Teach* Existing Software

He is currently working on books on word-processing, and report production using Microsoft Word, and a booklet on Professional Presentations.

The writing of the books is the first stage envisaged by Vijay for improving efficiency and productivity across the world. This directly leads to the second stage of his vision for productivity improvement in offices worldwide.

## **Stage two:** *Improving* on Existing Software

The next stage is the construction of software that will radically improve the usability of current Office software.

Vijay's first software is undergoing testing prior to its release in Jan 2003. The software — titled "Word Usability Enhancer" — will revolutionize the way users interact with Microsoft Word, providing users with a more intuitive interface, readily accessible tutorials, and numerous timesaving and annoyance-removing macros and utilities.

He plans to create a similar tool for Microsoft Excel, and, depending on resource constraints and demand, for PowerPoint, Star Office, etc.

**Stage 3: Construction** of the first “feedback-designed” Office and Statistics software

Vijay’s **eventual goal** is the construction of productivity software that will provide stiff competition to Microsoft Office. His hope is that the success of the software tools and the books will convince financiers to provide enough capital so that a successful software development and marketing endeavor can take a chunk of the **multi-billion dollar** Office Suite market.

Prior to the construction of the Office software, Vijay plans to construct the “Definitive” statistics software. Years of working on and teaching the current statistical software has made Vijay a master at picking out the weaknesses, limitations, annoyances, and, sometimes, pure inaccessibility of existing software. This **1.5 billion dollar** market needs a new visionary tool, one that is appealing and inviting to users, and not forbidding, as are several of the current software. Mr. Gupta wants to create integrated software that will encompass the features of SPSS, STATA, LIMDEP, EViews, STATISTICA, MINITAB, etc.

**Other**

He has plans for writing books on the “learning process.” The books will teach how to understand one’s approach to problem solving and learning and provide methods for learning new techniques for self-learning.

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**Mapping of menu options with sections of the book  
and in the series of books**

You may be looking for a section that pertains to a particular menu option in Excel. I now briefly lay out where to find (in the series) a discussion of a specific menu option of Excel.

Table 1: Mapping of the options in the “FILE” menu

<i>Menu Option</i>	<i>Section that discusses the option</i>
OPEN SAVE SAVE AS	<i>Volume 1: Excel For Beginners</i>  <i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
SAVE AS WEB PAGE	<i>Volume 1: Excel For Beginners</i>  <i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
SAVE WORKSPACE	<i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
SEARCH	<i>Volume 1: Excel For Beginners</i>
PAGE SETUP	<i>Volume 1: Excel For Beginners</i>
PRINT AREA	<i>Volume 1: Excel For Beginners</i>
PRINT PREVIEW	<i>Volume 1: Excel For Beginners</i>
PRINT	<i>Volume 1: Excel For Beginners</i>
PROPERTIES	<i>Volume 1: Excel For Beginners</i>

Table 2: Mapping of the options in the “EDIT” menu

<i>Menu Option</i>	<i>Section that discusses the option</i>
UNDO	<i>Volume 1: Excel For Beginners</i>
REDO	<i>Volume 1: Excel For Beginners</i>
CUT COPY	Various

<i>Menu Option</i>	<i>Section that discusses the option</i>
PASTE	
OFFICE CLIPBOARD	<i>Volume 1: Excel For Beginners</i>
PASTE SPECIAL	<i>Volume 3: Excel– Beyond The Basics</i>
FILL	<i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
CLEAR	<i>Volume 1: Excel For Beginners</i>
DELETE SHEET	<i>Volume 1: Excel For Beginners</i>
MOVE OR COPY SHEET	<i>Volume 1: Excel For Beginners</i>
FIND	<i>Volume 1: Excel For Beginners</i>
REPLACE	<i>Volume 1: Excel For Beginners</i>
GO TO	<i>Volume 3: Excel– Beyond The Basics</i>
LINKS	<i>Volume 3: Excel– Beyond The Basics</i>
OBJECT	<i>Volume 3: Excel– Beyond The Basics</i> <i>Volume 2: Charting in Excel</i>

Table 3: Mapping of the options in the “VIEW“ menu

<i>Menu Option</i>	<i>Section that discusses the option</i>
NORMAL	<i>Volume 1: Excel For Beginners</i>
PAGE BREAK PREVIEW	<i>Volume 1: Excel For Beginners</i>
TASK PANE	<i>Volume 1: Excel For Beginners</i>
TOOLBARS	<i>Volume 1: Excel For Beginners</i> <i>Volume 3: Excel– Beyond The Basics</i>
FORMULA BAR	Leave it on (checked)
STATUS BAR	Leave it on (checked)
HEADER AND FOOTER	<i>Volume 1: Excel For Beginners</i>
COMMENTS	<i>Volume 3: Excel– Beyond The Basics</i>

<i>Menu Option</i>	<i>Section that discusses the option</i>
FULL SCREEN	<i>Volume 1: Excel For Beginners</i>
ZOOM	<i>Volume 1: Excel For Beginners</i>

Table 4: Mapping of the options in the “INSERT” menu

<i>Menu Option</i>	<i>Section that discusses the option</i>
CELLS	<i>Volume 1: Excel For Beginners</i>
ROWS	<i>Volume 1: Excel For Beginners</i>
COLUMNS	<i>Volume 1: Excel For Beginners</i>
WORKSHEETS	<i>Volume 1: Excel For Beginners</i>
CHARTS	<i>Volume 2: Charting in Excel</i>
PAGE BREAK	<i>Volume 1: Excel For Beginners</i>
FUNCTION	<i>Volume 1: Excel For Beginners</i> <i>Volume 3: Excel– Beyond The Basics</i>
FUNCTION/FINANCIAL	<i>Volume 6: Financial Analysis using Excel</i>
FUNCTION/STATISTICAL	chapter 6-chapter 8
FUNCTION/LOGICAL	<i>Volume 3: Excel– Beyond The Basics</i>
FUNCTION/TEXT	<i>Volume 3: Excel– Beyond The Basics</i>
FUNCTION/INFORMATION	<i>Volume 3: Excel– Beyond The Basics</i>
FUNCTION/LOOKUP	<i>Volume 3: Excel– Beyond The Basics</i>
FUNCTION/MATH & TRIG	<i>Volume 3: Excel– Beyond The Basics</i>
FUNCTION/ENGINEERING	section 30.2-section 30.3
FUNCTION/DATABASE	<i>Volume 3: Excel– Beyond The Basics</i> <i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
FUNCTION/DATE & TIME	<i>Volume 3: Excel– Beyond The Basics</i>
NAME	<i>Volume 1: Excel For Beginners</i>

<i>Menu Option</i>	<i>Section that discusses the option</i>
COMMENT	<i>Volume 3: Excel– Beyond The Basics</i>
PICTURE	<i>Volume 2: Charting in Excel</i>
DIAGRAM	<i>Volume 2: Charting in Excel</i>
OBJECT	<i>Volume 3: Excel– Beyond The Basics</i>
HYPERLINK	<i>Volume 3: Excel– Beyond The Basics</i>

Table 5: Mapping of the options inside the “FORMAT” menu

<i>Menu Option</i>	<i>Section that discusses the option</i>
CELLS	<i>Volume 1: Excel For Beginners</i>
ROW	<i>Volume 1: Excel For Beginners</i>
COLUMN	<i>Volume 1: Excel For Beginners</i>
SHEET	<i>Volume 1: Excel For Beginners</i>
AUTOFORMAT	<i>Volume 1: Excel For Beginners</i>
CONDITIONAL FORMATTING	<i>Volume 3: Excel– Beyond The Basics</i>
STYLE	<i>Volume 1: Excel For Beginners</i>

Table 6: Mapping of the options inside the “TOOLS” menu

<i>Menu Option</i>	<i>Section that discusses the option</i>
SPELLING	<i>Volume 1: Excel For Beginners</i>
ERROR CHECKING	<i>Volume 3: Excel– Beyond The Basics</i>
SPEECH	<i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
SHARE WORKBOOK	<i>Volume 3: Excel– Beyond The Basics</i>
TRACK CHANGES	<i>Volume 3: Excel– Beyond The Basics</i>
PROTECTION	<i>Volume 3: Excel– Beyond The Basics</i>



<i>Menu Option</i>	<i>Section that discusses the option</i>
ONLINE COLLABORATION	<i>Volume 3: Excel– Beyond The Basics</i>
GOAL SEEK	<i>Volume 3: Excel– Beyond The Basics</i>
SCENARIOS	<i>Volume 3: Excel– Beyond The Basics</i>
AUDITING	<i>Volume 3: Excel– Beyond The Basics</i>
TOOLS ON THE WEB	The option will take you to a Microsoft site that provides access to resources for Excel
MACROS	In upcoming book on “Macros for Microsoft Office”
ADD-INS	chapter 9
AUTOCORRECT	<i>Volume 1: Excel For Beginners</i>
CUSTOMIZE	<i>Volume 3: Excel– Beyond The Basics</i>
OPTIONS	<i>Volume 1: Excel For Beginners</i>

Table 7: Mapping of the options inside the “DATA” menu

<i>Menu Option</i>	<i>Section that discusses the option</i>
SORT	<i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
FILTER	<i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
FORM	<i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
SUBTOTALS	<i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
VALIDATION	<i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
TABLE	<i>Volume 1: Excel For Beginners</i>
CONSOLIDATION	section 48.5
GROUP AND OUTLINE	<i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
PIVOT REPORT	<i>Volume 4: Managing &amp; Tabulating Data in Excel</i>
EXTERNAL DATA	<i>Volume 4: Managing &amp; Tabulating Data in Excel</i>

Table 8: Mapping of the options inside the “WINDOW“ menu

<i>Menu Option</i>	<i>Section that discusses the option</i>
HIDE	<i>Volume 3: Excel– Beyond The Basics</i>
SPLIT	<i>Volume 1: Excel For Beginners</i>
FREEZE PANES	<i>Volume 1: Excel For Beginners</i>

Table 9: Mapping of the options inside the “HELP“ menu

<i>Menu Option</i>	<i>Section that discusses the option</i>
OFFICE ASSISTANT	<i>Volume 1: Excel For Beginners</i>
HELP	<i>Volume 1: Excel For Beginners</i>
WHAT’S THIS	<i>Volume 1: Excel For Beginners</i>

# INTRODUCTION

Are there not enough Excel books in the market? I have asked myself this question and concluded that there are books “inside me,” based on what I have realized from observation by friends, students, and colleagues that I have a “vision and knack for explaining technical material in plain English.”

Read the book practicing the lessons on the sample files provided in the zipped file you downloaded. I hope the book is useful and assists you in increasing your productivity in Excel usage. You may be pleasantly surprised at some of the features shown here. They will enable you to save time.

The “Make me a Guru” series teach technical material in simple English. A lot of thinking went into the sequencing of chapters and sections. The book is broken down into logical “functional” components. Chapters are organized into sections and sub-sections. This creates a smooth flowing structure, enabling “total immersion” learning. The current book is broken down into a multi-level hierarchy:

- Chapters, each teaching a specific skill/tool.
  
- Several sections within each chapter. Each section shows aspect of the skill/tool taught in the chapter. Each section is numbered—for example, “Section 1.2” is the numbering for the second section in chapter 1.
  
- A few sub-sections (and maybe one further segmentation) within each section. Each sub-section lists a specific function, task, or proviso related to the “master” section. The sub-sections are numbered—for example, “1.2.a” for the first sub-section in the second section of chapter 1.

Unlike other publishers, I do not consider you dummies or idiots. Each and everyone had the God given potential to achieve mastery in any field. All one needs is a guide to show you the way to master a field. I hope to play this role. I am confident that you will consider your self an Excel “Guru” (in terms of the typical use of Excel in your profession) and so will others.

Once you learn the way to master a windows application, this new approach will enable you to pick up new skills” on the fly.” Do not argue for your limitations. You have none.

I hope you have a great experience in learning with this book. I would love feedback. Please use the feedback form on our website [vjbooks.net](http://vjbooks.net). In addition, look for updates and sign up for an infrequent newsletter at the site.

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## STATISTICS PROCEDURES

Three chapters teach statistics functions including the use of Excel functions for building Confidence Intervals and conducting Hypothesis Testing for several types of distributions. The design of hypothesis tests and the intermediate step of demarcating critical regions are taught lucidly.

It seems that Microsoft has taken pains to “hide” some of the most powerful tools in Excel. These “hidden” tools are called “Add-Ins.” These tools work on top of Excel, extending the power and abilities of Excel. Many Add-Ins are available for specific types of analysis like Risk Analysis. I show how to use three Add-Ins that install with Excel.

## BASICS

The fundamental operations in Excel are taught in *Volume 1: Excel For Beginners*, *Volume 2: Charting in Excel*, and *Volume 3: Excel– Beyond The Basics*

## FUNCTIONS

I teach the writing of formulas and associated topics in *Volume 3: Excel– Beyond The Basics*. I show, in a step-by-step exposition, the proper way for writing cell references in a formula. The book describe tricks for copying/cutting and pasting in several examples. In addition, I discuss special pasting options.

Finally, different types of functions are classified under logical categories and discussed within the optimal category. The categories include financial, Statistical, Text, Information, Logical, and “Smart” Logical.

## MANAGING & TABULATING DATA

Excel has extremely powerful data entry, data management, and tabulation tools. The combination of tools provide almost database like power to Excel. Unfortunately, the poor quality of the menu layout and the help preclude the possibility of the user self-learning these features. These features are taught in *Volume 4: Managing & Tabulating Data in Excel*

## CHARTING

Please refer to book two in this series. The book title is *Charting in Excel*.

## Sample data

Most of the tutorials use publicly available data from the International labor Organization (ILO). I used a simple data set with only a few columns and observations. All the sample data files are included in the zipped file.

The samples for functions use several small data sets that are more suited to illustrating the power and usefulness of the functions.

I have not included the data set for conducting statistical procedures. This is intentional; often, readers fail to internalize the few key concepts of hypothesis testing because they do not subject themselves to a “sink-or-swim” inference-drawing thinking and imbibing process when interpreting the results of statistical procedures.

# **CHAPTER 1**

## WRITING FORMULAS

This chapter discusses the following topics:

- THE BASICS OF WRITING FORMULAE
- TOOL FOR USING THIS CHAPTER EFFECTIVELY: VIEWING THE FORMULA INSTEAD OF THE END RESULT
- The A1 VS THE R1C1 STYLE OF CELL REFERENCES
- TYPES OF REFERENCES ALLOWED IN A FORMULA
- REFERENCING CELLS FROM ANOTHER WORKSHEET
- REFERENCING A BLOCK OF CELLS
- REFERENCING NON-ADJACENT CELLS
- REFERENCING ENTIRE ROWS
- REFERENCING ENTIRE COLUMNS
- REFERENCING CORRESPONDING BLOCKS OF CELLS/ROWS/COLUMNS FROM A SET OF WORKSHEETS

The most important functionality offered by a spreadsheet application is the ease and flexibility of writing formulae. In this chapter, I start by showing how to write simple formula and then build up the level of complexity of the formulae.

Within the sections of this chapter, you will find tips and notes on commonly encountered problems or issues in formula writing.



1.1

## **THE BASICS OF WRITING FORMULAE**

This section teaches the basics of writing functions.

---

1.2

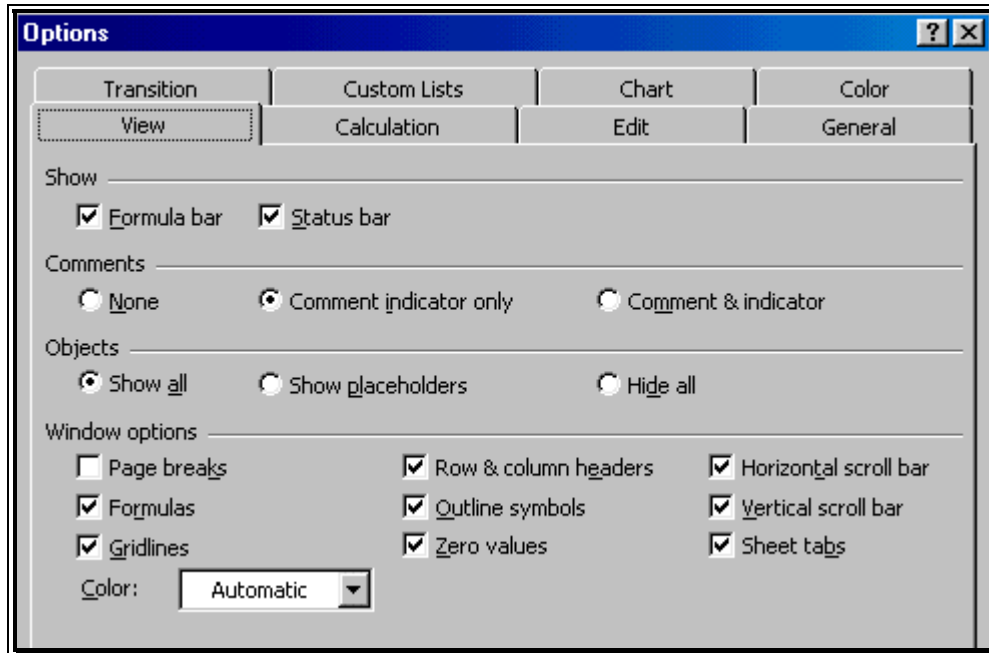
### **TOOL FOR USING THIS CHAPTER EFFECTIVELY: VIEWING THE FORMULA INSTEAD OF THE END RESULT**

For ease of understanding this chapter, I suggest you use a viewing option that shows, in each cell on a worksheet, the formula instead of the result. Follow the menu path **TOOLS/OPTIONS/VIEW**. In the area “Window Options” select the option “Formulas” as shown in Figure 1.

Execute the dialog by clicking on the button **OK**. Go back to the worksheet. The formula will be shown instead of the calculated value.

Eventually you will want to return to the default of seeing the results instead of the formula. Deselect “formula” in the area “Windows Options” in **TOOLS/OPTIONS/VIEW**.

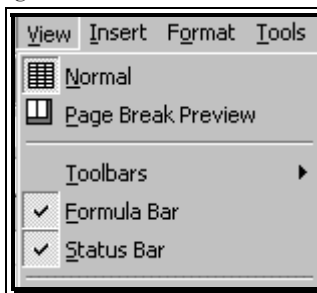
Figure 1: Viewing the formulas instead of the formula result



The effect is only cosmetic; the results will not change. As you shall see later, what you have just done will facilitate the understanding of functions.

In addition, leave the option VIEW/ FORMULA BAR selected as shown in Figure 2.

Figure 2: Select "Formula Bar"

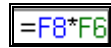


## 1.2.A

**THE “A1” VS. THE “R1C1” STYLE OF CELL REFERENCES**

The next figure shows a simple formula. The formula is written into cell G15. The formula multiplies the values inside cells F8 and F6.

Figure 3: A1-style cell referencing

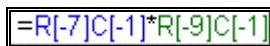


=F8\*F6

This style of referencing is called the “A1” style or “absolute” referencing. The exact location of the referenced cells is written. (The cells are those in the 6th and 8th rows of column F.) One typically works with this style.

However, there is another style for referencing the cells in a formula. This style is called the “R1C1” style or “relative” referencing. The same formula as in the previous figure but in R1C1 style is shown in the next figure.

Figure 4: The same formula as in the previous figure, but in R1C1 (Offset) style cell referencing while the previous figure showed A1 (Absolute-) style cell referencing

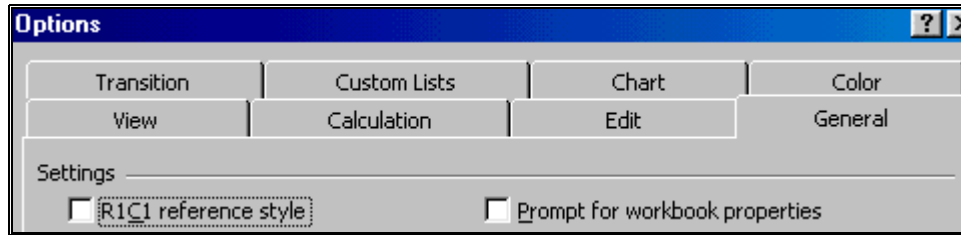


=R[-7]C[-1]\*R[-9]C[-1]

Does not this formula look different? This style uses relative referencing. So, the first cell (F8) is referenced relative to its position in reference to the cell that contains the formula (cell G15). Row 8 is 7 rows below row 15 and column F is 1 column before column G. Therefore, the cell reference is “minus seven rows, minus 1 column” or “R[— 7]C[— 1].”

If you see a file or worksheet with such relative referencing, you can switch all the formulas back to absolute “A1” style referencing by going to **TOOLS/OPTIONS/GENERAL** and deselecting the option “R1C1 reference style.”

Figure 5: Settings for Formula Referencing



1.2.B

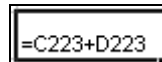
**WRITING A SIMPLE FORMULA THAT REFERENCES CELLS**

Open the sample file “File3.xls” and choose the worksheet “main.”

Assume you want to write add the values in cells C223<sup>1</sup> and D223 (that is, to calculate “C223 + D223”) and place the result into cell F223.

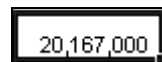
Click on cell F223. Key-in “=” and then write the formula by clicking on the cell C223, typing in “+” then clicking on cell “D223.”

Figure 6: Writing a formula

A screenshot of a single cell in an Excel spreadsheet. The cell contains the text formula "=C223+D223".

After writing in the formula, press the key ENTER. The cell F223 will contain the result for the formula contained in it.

Figure 7: The result is shown in the cell on which you wrote the formula

A screenshot of a single cell in an Excel spreadsheet. The cell contains the numerical result "20,167,000".

---

<sup>1</sup> Cell C223 is the cell in column C and row 223.

1.3

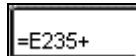
**TYPES OF REFERENCES ALLOWED IN A FORMULA**

1.3.A

**REFERENCING CELLS FROM ANOTHER WORKSHEET**

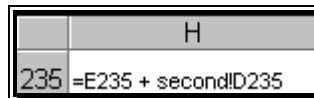
You can reference cells from another worksheet. Choose cell H235 on the worksheet “main.” In the chosen cell, type the text shown in the next figure. (Do not press the ENTER key; the formula is incomplete and you will get an error message if you press ENTER.)

Figure 8: Writing or choosing the reference to the first referenced range



Then select the worksheet “second” and click on cell D235. Now press the ENTER key. The formula in cell H235 of worksheet “main” references the cell D235 from the worksheet “second”. The next figure illustrates this.

Figure 9: Writing or choosing the reference to the second referenced range which is not on the worksheet on which you are writing the formula



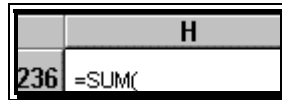
In this formula, the part “second!” informs Excel that the range referenced is from the sheet “second.”

1.3.B

**REFERENCING A BLOCK OF CELLS**

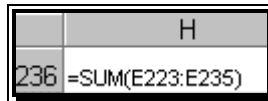
Select the worksheet “main.” Choose cell H236. In the chosen cell, type the text shown in the next figure.

Figure 10: This formula requires a block of cells as a reference



Use the mouse to highlight the block of cells “E223 to E235.” Type in a closing parenthesis and press the ENTER key. The resulting function is shown in the next figure.

Figure 11: Formula with a block of cells as the reference

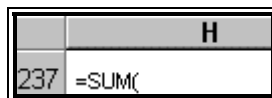


1.3.C

**REFERENCING NON-ADJACENT CELLS**

Choose cell H237. Click in the cell and type the text shown in the next figure.

Figure 12: The core function is typed first



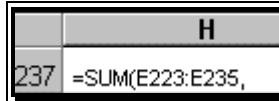
As in the previous example, choose cells E223 to E235 by highlighting them—the formula should like the one shown in the next figure.

Figure 13: The first block of cells is referenced



Type a comma. The resulting formula should look like that shown in the next figure.

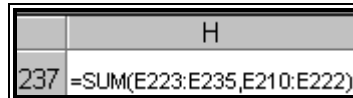
Figure 14: Getting the formula ready for the second block of cells



	H
237	=SUM(E223:E235,

Highlight the block of cells “E210 to E222.” Key-in a closing parenthesis and press the ENTER key.

Figure 15: The formula with references to two non-adjacent blocks of cells



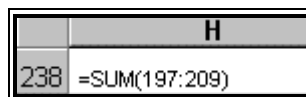
	H
237	=SUM(E223:E235,E210:E222)

### 1.3.D REFERENCING ENTIRE ROWS

Choose cell H238. In this cell, type the text shown in the next figure.

Using the mouse, highlight the rows 197 to 209. Type in a closing parenthesis and press the ENTER key. The resulting formula is shown in the next figure.

Figure 16: Referencing entire rows



	H
238	=SUM(197:209)

### 1.3.E REFERENCING ENTIRE COLUMNS

Choose cell H239. In this cell, type the text shown in the next figure. Using the mouse, highlight the columns C and D. Key-in a closing parenthesis and press the ENTER key.

Figure 17: Referencing entire columns



1.3.F

### REFERENCING CORRESPONDING BLOCKS OF CELLS/ROWS/COLUMNS FROM A SET OF WORKSHEETS

Assume you have a workbook with six worksheets on similar data from six clients. You want to sum cells “C4 to F56” across all six worksheets.

One way to do this would be to create a formula in each worksheet to sum for that worksheet’s data and then a formula to add the results of the other six formulae.

Another way is using “3-D references.” The row and column make the first two dimensions; the worksheet set is the third dimension. You can use only one formula that references all six worksheets that the relevant cells within them.

While typing the formula,

- Type the “=” sign,
- Write the formula (for example, “Sum”),
- Place an opening parenthesis “(,” then
- Select the six worksheets by clicking at the name tab of the first one and then pressing down SHIFT and clicking on the name tab of the sixth worksheet, and then
- Highlight the relevant cell range on any one of them,
- Type in the closing parenthesis “)”
- And press the ENTER key to get the formula

```
=SUM(Sheet1:Sheet6!"C4:F56")
```





## **CHAPTER 2**

# COPYING/CUTTING AND PASTING FORMULAE

This chapter teaches the following topics:

- COPYING AND PASTING A FORMULA TO OTHER CELLS IN THE SAME COLUMN
- COPYING AND PASTING A FORMULA TO OTHER CELLS IN THE SAME ROW
- COPYING AND PASTING A FORMULA TO OTHER CELLS IN A DIFFERENT ROW AND COLUMN
- CONTROLLING CELL REFERENCE BEHAVIOR WHEN COPYING AND PASTING FORMULAE (USE OF THE “\$” KEY)
- USING THE “\$” SIGN IN DIFFERENT PERMUTATIONS AND COMPUTATIONS IN A FORMULA.
- COPYING AND PASTING FORMULAS FROM ONE WORKSHEET TO ANOTHER
- SPECIAL PASTE OPTIONS
- PASTING ONLY THE FORMULA (BUT NOT THE FORMATTING AND COMMENTS)
- PASTING THE RESULT OF A FORMULA, BUT NOT THE FORMULA ITSELF
- CUTTING AND PASTING FORMULAE
- THE DIFFERENCE BETWEEN “COPYING AND PASTING” FORMULAS AND “CUTTING AND PASTING” FORMULAS

— SAVING TIME BY WRITING, COPYING AND PASTING  
FORMULAS ON SEVERAL WORKSHEETS  
SIMULTANEOUSLY

---

2.1

**COPYING AND PASTING A FORMULA TO OTHER  
CELLS IN THE SAME COLUMN**

Often one wants to write analogous formulae for several cases. For example, assume you want to write a formula analogous to the formula in F223 into each of the cells F224 to F235<sup>2</sup>. The quick way to do this is to:

- Click on the “copied from” cell F223.
- Select the option EDIT/COPY. (The menu can also be accessed by right-clicking on the mouse or by clicking on the COPY icon.)
- Highlight the “pasted on” cells F224 to F235 and
- Choose the menu option EDIT/PASTE. (The menu can also be accessed by right-clicking on the mouse or by clicking on the PASTE icon.)
- Press the ENTER key.
- The formula is pasted onto the cells F224 to F235 and the cell

---

<sup>2</sup> The formula in F223 adds the values in cells that are 3 and 2 columns to the left (that is, cells in columns in C and D.)

references within each formula are adjusted<sup>3</sup> for the location difference between the “pasted on” cells and the “copied from” cell.

Figure 18: Pasting a formula

	C	D	E	F
223	9133000	11034000	15223000	=C223+D223
224	1626000	1852000	2818000	=C224+D224
225	1417000	1600000	2255000	=C225+D225
226	1202000	1389000	1802000	=C226+D226
227	976000	1176000	1550000	=C227+D227
228	607000	951000	1339000	=C228+D228
229	464000	589000	1124000	=C229+D229
230	396000	447000	897000	=C230+D230
231	331000	375000	544000	=C231+D231
232	279000	307000	400000	=C232+D232
233	221000	250000	319000	=C233+D233

## 2.2

## COPYING AND PASTING A FORMULA TO OTHER CELLS IN THE SAME ROW

Select the range F223— F235 (which you just created in the previous subsection). Select the option EDIT/COPY. Choose the range G223— G235 (that is, one column to the right) and choose the menu option EDIT/PASTE. Now click on any cell in the range G223— G235 and see how the column reference has adjusted automatically. The formula in

<sup>3</sup> The formula in the “copied cell” F223 is “C223 + D223” while the formula in the “pasted on” cell F225 is “C225 + D225.” (Click on cell F225 to confirm this.) The cell F225 is two rows below the cell F223, and the copying-and-pasting process accounts for that.

G223 is “D223 + E223” while the formula in F223 was “C223 + D223”.

The next figure illustrates this. Because you pasted one column to the right, the cell references automatically shifted one column to the right. So:

- The reference “C” became “D,” and
- The reference “D” became “E.”

Figure 19: Cell reference changes when a formula is copied and pasted

	F	G
223	=C223+D223	=D223+E223
224	=C224+D224	=D224+E224
225	=C225+D225	=D225+E225
226	=C226+D226	=D226+E226
227	=C227+D227	=D227+E227
228	=C228+D228	=D228+E228
229	=C229+D229	=D229+E229
230	=C230+D230	=D230+E230

The examples in 2.1 on page 36 and 2.2 on page 37 show the use of “Copy and Paste” to quickly replicate formula in a manner that maintains referential parallelism.

### 2.3

## COPYING AND PASTING A FORMULA TO OTHER CELLS IN A DIFFERENT ROW AND COLUMN

Select the cell F223. Select the option EDIT/COPY. Choose the range H224 (that is, two columns to the right and one row down from the copied cell) and choose the menu option EDIT/PASTE. Observe how the column and row references have changed automatically—the formula in H224 is

“E224 + F224” while the formula in F223 was “C223 + D223”.

The next figure illustrates this. Because you pasted two columns to the right and one row down, the cell references automatically shifted two columns to the right and one row down. So:

- The reference “C” became “E” (that is, two columns to the right)
- The reference “D” became “F” (that is, two columns to the right)
- The references “223” became “224” (that is, one row down)

Figure 20: Copying and pasting a formula

F	G	H
=C223+D223	=D223+E223	
=C224+D224	=D224+E224	=E224+F224

## 2.4

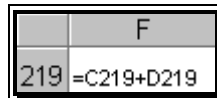
### **CONTROLLING CELL REFERENCE BEHAVIOR WHEN COPYING AND PASTING FORMULAE (USE OF THE “\$” KEY)**

The use of the dollar key “\$” (typed by holding down SHIFT and choosing the key “4”) allows you to have control over the change of cell references in the “Copy and Paste” process. The use of this feature is best shown with some examples.

- The steps in copy and pasting a formula from one range to another:
- Click on the “copied from” cell F223.
- Select the option EDIT/COPY. (The menu can also be accessed by right-clicking on the mouse or by clicking on the COPY icon.)

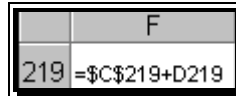
- 
- Choose the “pasted on” cell F219 by clicking on it, and
  - Select the menu option EDIT/PASTE. (The menu can also be accessed by right-clicking on the mouse or by clicking on the PASTE icon.)
  - Press the ENTER key.
  - The formula “C219 + D219” will be pasted onto cell F219. (For a pictorial reproduction of this, see Figure 21.)

Figure 21: The “pasted-on” cell



Change the formula by typing the dollar signs as shown Figure 22.

Figure 22: Inserting dollar signs in order to influence cell referencing



Copy cell F219. Paste into G220 (that is, one column to the right and one row down). The dollar signs will ensure that the cell reference is not adjusted for the row or column differential for the parts of the formula that have the dollar sign before them<sup>4</sup>— see the formula in cell F220 (reproduced in Figure 23).

---

<sup>4</sup> In this example, the parts are the “C” reference and “219” reference in “\$C\$219” part of the formula.

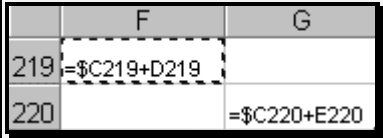
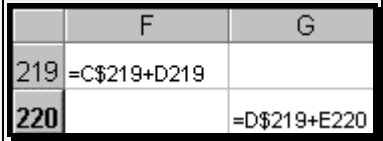
Figure 23: The “copied-from” and “pasted-on” cells with the use of the dollar sign

	F	G
219	= $\$C\$219 + D219$	
220		= $\$C\$219 + E220$

For the parts of the cell that do not have the dollar sign before them, the cell references adjust to maintain referential integrity<sup>5</sup>.

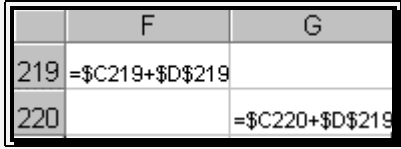
2.4.A

**USING THE “\$” SIGN IN DIFFERENT PERMUTATIONS AND COMPUTATIONS IN A FORMULA**

<p>The dollar sign in the “copied from” cell</p>	<p>The copy &amp; paste action</p>	<p>The cell references in the “pasted on” cell depend on the location of the dollar signs in the formula in the original, “copied from” cell</p>
<p>Reference behavior with a dollar sign before one of the column references</p> <p>Original cell: F219 = <math>\\$C219 + D219</math></p>	<p>Copy F219 and paste into G220.</p>	<p>Figure: 24: Only the reference to “C” does not adjust because only “C” has a dollar prefix</p> 
<p>Reference behavior with a dollar sign before one of the row references</p> <p>Original cell: F219 = <math>C\\$219 + D219</math></p>	<p>Copy F219 and paste into G220.</p>	<p>Figure 25: Only the reference to “219” (in the formula part “C\$219”) does not adjust because only that “219” has a dollar prefix</p> 

<sup>5</sup> The part “D219” adjusts to “E220” to adjust for the fact that the “pasted on” cell is one column to the right (so “D→E”) and one row below (so “219→220”).



The dollar sign in the “copied from” cell	The copy & paste action	The cell references in the “pasted on” cell depend on the location of the dollar signs in the formula in the original, “copied from” cell
Reference behavior with a dollar sign before all but one of the row/column references  Original cell:  F219 = \$C219 + \$D\$219	Copy F219 and paste into G220.	Figure 26: the references to “C,” “D” and to “219” (in the formula part “\$D\$219”) do not adjust because they all have a dollar prefix  
Original cell:  F219 = \$C\$219 + \$D\$219	Copy F219 and paste into G220.	Try it...  G220 = \$C\$219 + \$D\$219
Original cell:  F219 = \$C219 + \$D219	Copy F219 and paste into G220.	Try it...  G220 = \$C220 + \$D220
Original cell:  F219 = C219 + \$D\$219	Copy F219 and paste into G220.	Try it...  G220 = D220 + \$D\$219

## 2.5

## COPYING AND PASTING FORMULAS FROM ONE WORKSHEET TO ANOTHER

The worksheet “second” in the sample data file has the same data as the worksheet you are currently on (“main.”) In the worksheet main, select the cell F219 and choose the menu option EDIT/COPY. Select the worksheet “second” and paste the formula into cell F219. Notice that the formula is duplicated.

2.6

---

**PASTING ONE FORMULA TO MANY CELLS,  
COLUMNS, ROWS**

Copy the formula. Select the range for pasting and paste or “Paste Special” the formula.

2.7

---

**PASTING SEVERAL FORMULAS TO A SYMMETRIC  
BUT LARGER RANGE**

Assume you have different formulas in cells G2, H2, and I2. You want to paste the formula:

— In G2 to G3:G289

— In H2 to H3:H289

— In I2 to I3:I289

Select the range G2:I2. Pick the menu option EDIT/COPY. Highlight the range G3:I289. (Shortcut: select G3. Scroll down to I289 without touching the sheet. Depress the SHIFT key and click on cell I289.) Pick the menu option EDIT/PASTE.

2.8

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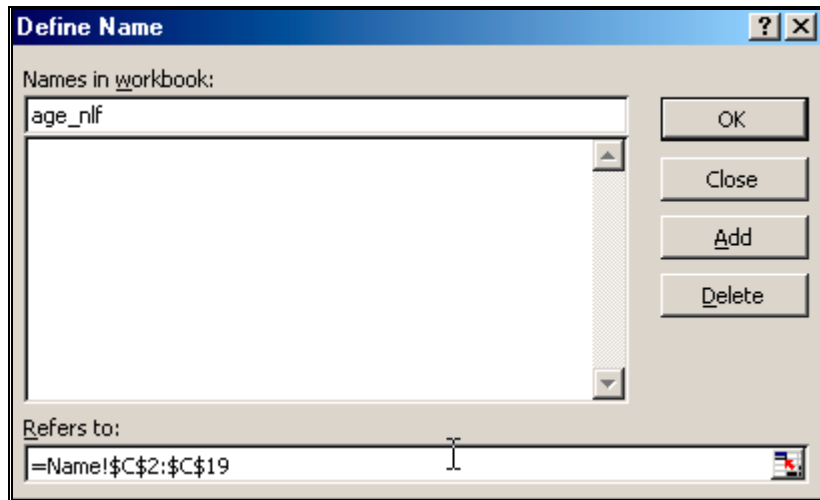
**DEFINING AND REFERENCING A “NAMED RANGE”**

You can use range names as references instead of exact cell references. Named ranges are easier to use if the names chosen are explanatory.

First, you have to define named ranges. This process involves informing Excel that the name, for example, “age\_nlf,” refers to the range “C2:C19.”

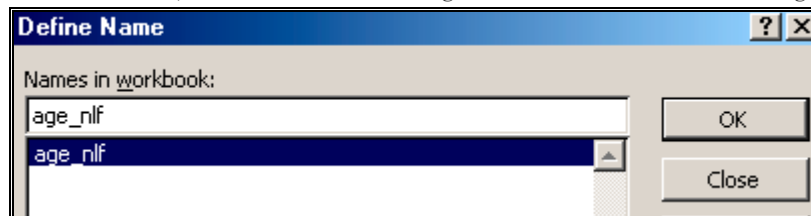
Pick the menu option “INSERT/NAME/DEFINE.” The dialog (user-input form) that opens is shown in the next figure. Type the name of the range into the text-box “Names in workbook” and the “Cell References” in the box “Refers to:” See the next figure for an example.

Figure 27: The DEFINE NAMES dialog



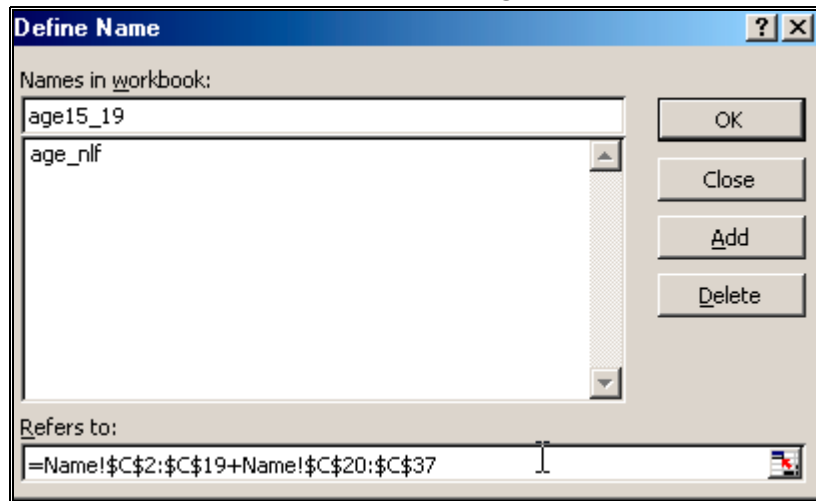
Click on the button “Add.” The named range is defined. The name of a defined range is displayed in the large text-box in the dialog. The next figure illustrates this text.

Figure 28: Once added, the defined named range’s name can be seen in the large text-box



Several named ranges can be defined. A named range can represent multiple blocks of cells.

Figure 29: Defining a second named range. On clicking “Add,” the named range is defined, as shown in the next figure.



You can view the ranges represent by any name. Just click on the name in the central text-box and the range represented by the name will be displayed in the bottom box.

Figure 30: Two named ranges are defined

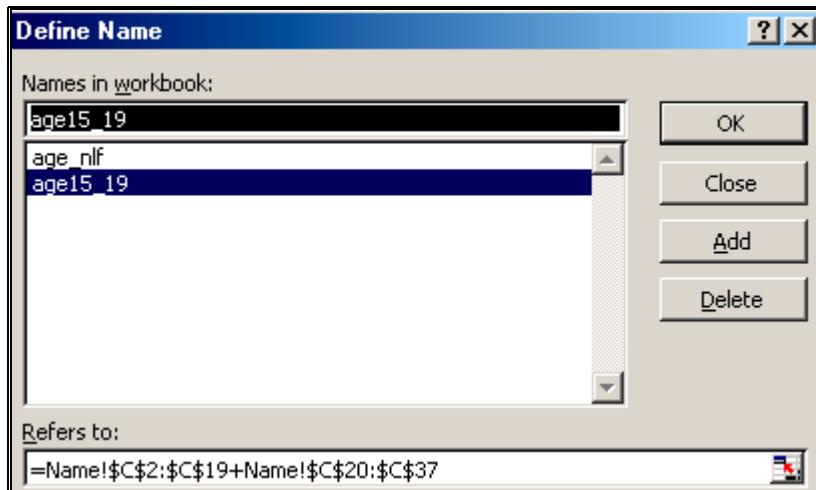
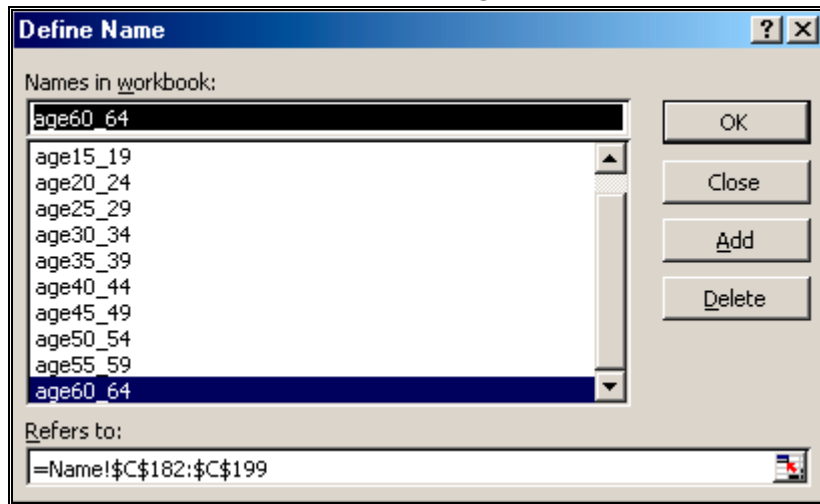


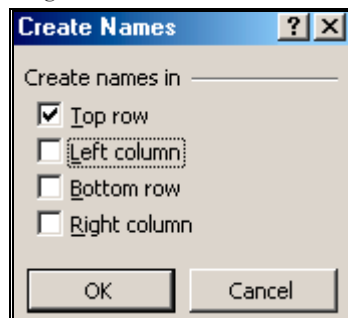
Figure 31: You can define many ranges. Just make sure that the names are explanatory and not confusing.



### Adding several named ranges in one step

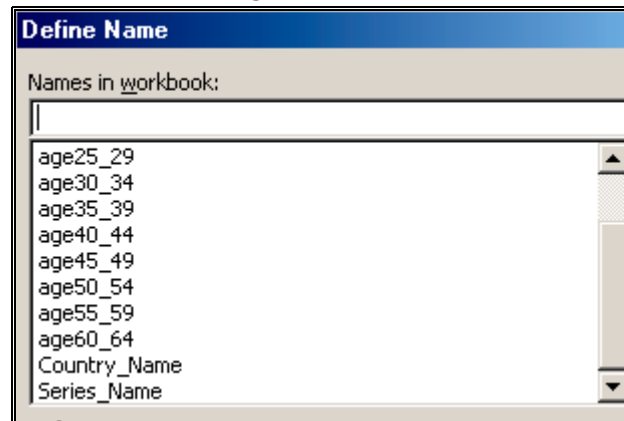
If the first/last row/column in your ranges has the labels for the range, then you can define names for all the ranges using the menu option INSERT/NAMES/CREATE. The dialog is reproduced in the next figure.

Figure 32: CREATE NAMES



In our sample data set, I selected columns “A” and “B” and created the names from the labels in the first row.

Figure 33: The named ranges “Country\_Name,” and “Series\_Name” were defined in one step using “Create Names”



### Using a named range

Named ranges are typically used to make formulas easier to read. The named ranges could also be used in other procedures

Assume you want to sum several of the ranges defined above. One way to sum them would be to select them one-by-one from the worksheet.

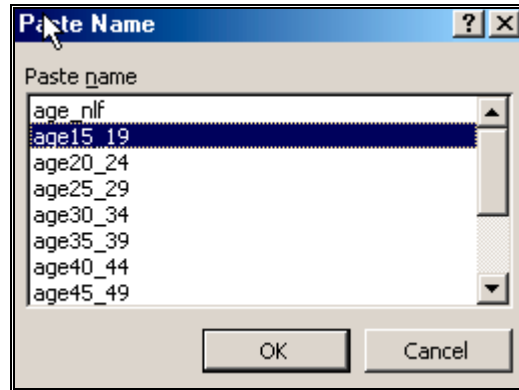
```
=SUM(
```

Another way is to use the menu option **INSERT/NAME/PASTE** to select and paste the names of the ranges. The names are explanatory and reduce the chances of errors in cell referencing.

A reference to the named range is pasted onto the formula as shown below.

```
=SUM(age15_19)
```

Figure 34: Pasting named ranges



---

2.9 **SELECTING ALL CELLS WITH FORMULAS THAT EVALUATE TO A SIMILAR NUMBER TYPE**

*Volume 3: Excel– Beyond The Basics.*

---

2.10 **SPECIAL PASTE OPTIONS**

2.10.A **PASTING ONLY THE FORMULA (BUT NOT THE FORMATTING AND COMMENTS)**

Refer to page 56 in chapter 3.

2.10.B **PASTING THE RESULT OF A FORMULA, BUT NOT THE FORMULA ITSELF**

Refer to page 53 in chapter 3.

2.11

**CUTTING AND PASTING FORMULAE**

2.11.A

**THE DIFFERENCE BETWEEN “COPYING AND PASTING” FORMULAS AND “CUTTING AND PASTING” FORMULAS**

Click on cell F223, select the option EDIT/CUT, click on cell H224 and choose the menu option EDIT/PASTE. The formula in the “pasted on” cell is the same as was in the “cut from” cell. (The formula “=C223 + D223.”) Therefore, there is no change in the cell references after cutting—and—pasting. While copy—and—paste automatically adjusts for cell reference differentials, cut—and—paste does not.

If you had used copy and paste, the formula in H224 would be “=D224 + E224.”

Figure 35: Cut from cell F223

	F	G	H
223	=C223+D223	=D223+E223	
224	=C224+D224	=D224+E224	

Figure 36: Paste into cell H223. Note that the cell references do not adjust.

	F	G	H
223		=D223+E223	
224	=C224+D224	=D224+E224	=C223+D223

After doing this, select the option EDIT/UNDO because I want to maintain the formulas in F223— F235 (and not because it is required for a cut and paste operation).



2.12

### **CREATING A TABLE OF FORMULAS USING DATA/TABLE**

The menu option DATA/TABLE supposedly offers a tool for creating an X-Y table of formula results. However, the method needs so much data arrangement that it is no better than using a simple copy and paste operation on cells!

---

2.13

### **SAVING TIME BY WRITING, COPYING AND PASTING FORMULAS ON SEVERAL WORKSHEETS SIMULTANEOUSLY**

Refer to *Volume 3: Excel– Beyond The Basics* to learn how to work with multiple worksheets. The section will request you to follow our example of writing a formula for several worksheets together.



## **CHAPTER 3**

### PASTE SPECIAL

This chapter teaches the following topics:

- PASTING THE RESULT OF A FORMULA, BUT NOT THE FORMULA
- OTHER SELECTIVE PASTING OPTIONS
- PASTING ONLY THE FORMULA (BUT NOT THE FORMATTING AND COMMENTS)
- PASTING ONLY FORMATS
- PASTING DATA VALIDATION SCHEMES
- PASTING ALL BUT THE BORDERS
- PASTING COMMENTS ONLY
- PERFORMING AN ALGEBRAIC “OPERATION” WHEN PASTING ONE COLUMN/ROW/RANGE ON TO ANOTHER
- MULTIPLYING/DIVIDING/SUBTRACTING/ADDING ALL CELLS IN A RANGE BY A NUMBER
- MULTIPLYING/DIVIDING THE CELL VALUES IN CELLS IN SEVERAL “PASTED ON” COLUMNS WITH THE VALUES OF THE COPIED RANGE
- SWITCHING ROWS TO COLUMNS

This less known feature of Excel has some great options that save time and reduce annoyances in copying and pasting.

## 3.1

**PASTING THE RESULT OF A FORMULA, BUT NOT THE FORMULA**

Sometimes one wants the ability to copy a formula (for example, “=C223 + D223”) but paste only the resulting value. (The example that follows will make this clear.)

Select the range “F223:F235” on worksheet “main.”

Choose the menu option FILE/NEW and open a new file. Go to any cell in this new file and choose the menu option EDIT/PASTE SPECIAL.

In the area “Paste,” choose the option “Values” as shown in Figure 37.

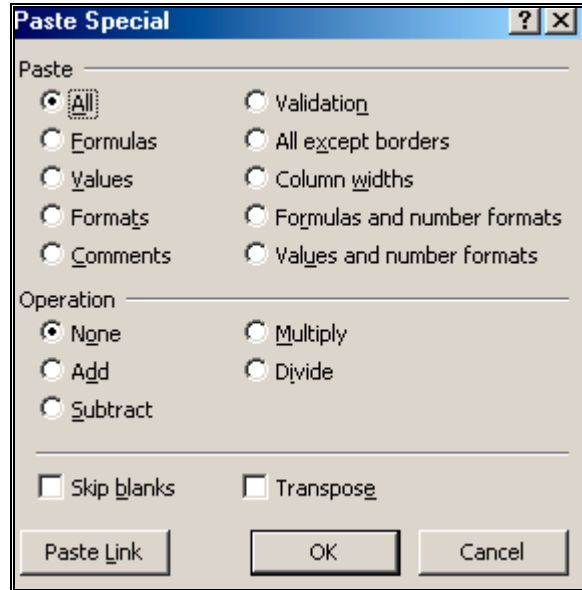
Figure 37: The PASTE SPECIAL dialog in Excel versions prior to Excel XP



In Excel XP, the “Paste Special” dialog has three additional options:

- Paste Formulas and number formats (and not other cell formatting like font, background color, borders, etc)
- Paste Values and number formats (and not other cell formatting like font, background color, borders, etc)
- Paste only “Column widths.”

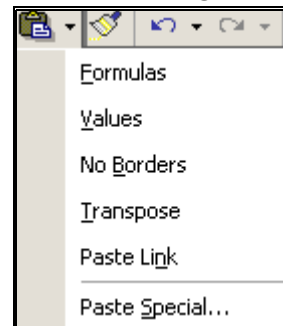
Figure 38: “Paste Special” dialog In Excel XP,



In Excel XP, the “Paste” icon provides quick access to some types of “Paste Special.” The options are shown in the next figure.

The calculated values in the “copied” cells are pasted. The formula is not pasted. Try the same experiment using EDIT/PASTE instead of EDIT/PASTE SPECIAL. The usefulness of the former will

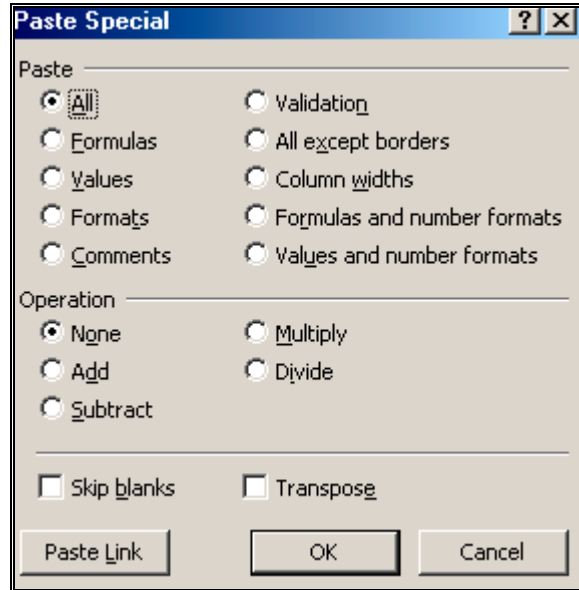
Figure 39: The pasting options can be accessed by clicking on the arrow to the right of the “Paste” icon



In Excel XP, the “Paste Special” dialog has three additional options:

- Paste Formulas and number formats (and not other cell formatting like font, background color, borders, etc)
- Paste Values and number formats (and not other cell formatting like font, background color, borders, etc)
- Paste only “Column widths.”

Figure 38: “Paste Special” dialog In Excel XP,



be apparent.

## 3.2

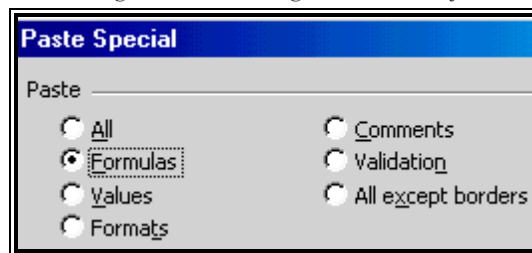
**OTHER SELECTIVE PASTING OPTIONS**

## 3.2.A

**PASTING ONLY THE FORMULA (BUT NOT THE FORMATTING AND COMMENTS)**

Choose the option “Formulas” in the area “Paste” of the dialog (user-input form) associated with the menu “EDIT/PASTE SPECIAL.” This feature makes the pasted values free from all cell references. The “pasted on” range will only contain pure numbers. The biggest advantage of this option is that it enables the collating of formula results in different ranges/sheets/workbooks onto one worksheet without the bother of maintaining all the referenced cells in the same workbook/sheet as the collated results.

Figure 40: Pasting formulas only



## 3.2.B

**PASTING ONLY FORMATS**

Choose the option “Formats” in the area “Paste” of the dialog associated with the menu “EDIT/PASTE SPECIAL use the “Format Painter” icon. I prefer using the icon.

Refer to *Volume 1: Excel For Beginners* for a discussion on the format painter.

## 3.2.C

**PASTING DATA VALIDATION SCHEMES**

Pick the option “Validation” in the area “Paste” of the dialog associated with the menu “EDIT/PASTE SPECIAL.” Data validation schemes are discussed in *Volume 4: Managing & Tabulating Data in Excel*. This option can be very useful in standardizing data entry standards and rules across an institution.

## 3.2.D

**PASTING ALL BUT THE BORDERS**

Choose the option “All except borders” in the area “Paste” of the dialog associated with the menu “EDIT/PASTE SPECIAL.” All other formatting features, formulae, and data are pasted. This option is rarely used.

## 3.2.E

**PASTING COMMENTS ONLY**

Pick the option “Comments” in the area “Paste” of the dialog associated with the menu “EDIT/PASTE SPECIAL.” Only the comments are pasted. The comments are pasted onto the equivalently located cell. For example, a comment on the cell that is in the third row and second column that is copied will be pasted onto the cell that is in the third row and second column of the “pasted on” range. This option is rarely used.



## 3.3

**PERFORMING AN ALGEBRAIC “OPERATION” WHEN PASTING ONE COLUMN/ROW/RANGE ON TO ANOTHER**

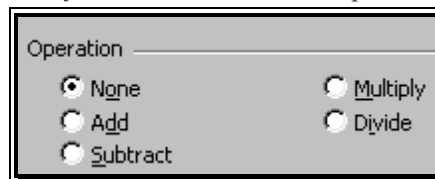
## 3.3.A

**MULTIPLYING/DIVIDING/SUBTRACTING/ADDING ALL CELLS IN A RANGE BY A NUMBER**

Assume your data is expressed in millions. You need to change the units to billions— that is, divide all values in the range by 1000. The complex way to do this would be to create a new range with each cell in the new range containing the formula “cell in old range/1000.” A much simpler way is to use PASTE SPECIAL. On any cell in the worksheet, write the number 1000. Click on that cell and copy the number. Choose the range whose cells need a rescaling of units. Go to the menu option EDIT/PASTE SPECIAL and choose “Divide” in the area *Options*. The range will be replaced with a number obtained by dividing each cell by the copied cells value!

The same method can be used to multiply, subtract or add a number to all cells in a range

Figure 41: You can multiply (or add/subtract/divide) all cells in the “pasted on” range by (to/by/from) the value of the copied cell



3.3.B

---

**MULTIPLYING/DIVIDING THE CELL VALUES IN CELLS IN SEVERAL “PASTED ON” COLUMNS WITH THE VALUES OF THE COPIED RANGE**

You can use the same method to add/subtract/multiply/divide one column's (or row's) values to the corresponding cells in one or several “pasted on” columns (or rows).

**Try this** Copy the cells in column E and paste special onto the cells in columns C and D choosing the option “Add” in the area “Operation” of the paste special dialog. (You can use EDIT/UNDO to restore the file to its old state.)

---

**3.4****SWITCHING ROWS TO COLUMNS**

Choose any option in the “Paste” and “Operations” areas and choose the option “Transpose.” If pasting a range with many columns and rows you may prefer to paste onto one cell to avoid getting the error “Copy and Paste areas are in different shapes.”



## **CHAPTER 4**

### INSERTING FUNCTIONS

This chapter teaches the following topics:

- A SIMPLE FUNCTION
- FUNCTIONS THAT NEED MULTIPLE RANGE REFERENCES
- WRITING A “FUNCTION WITHIN A FUNCTION“
- NEW IN EXCEL XP
- RECOMMENDED FUNCTIONS IN THE FUNCTION WIZARD
- EXPANDED AUTOSUM FUNCTIONALITY
- FORMULA EVALUATOR
- FORMULA ERROR CHECKING

---

#### 4.1

#### **BASICS**

Excel has many in-built functions. The functions may be inserted into a formula.

#### **Accessing the functions dialog/wizard**

(a) select the menu path INSERT/FUNCTION, or

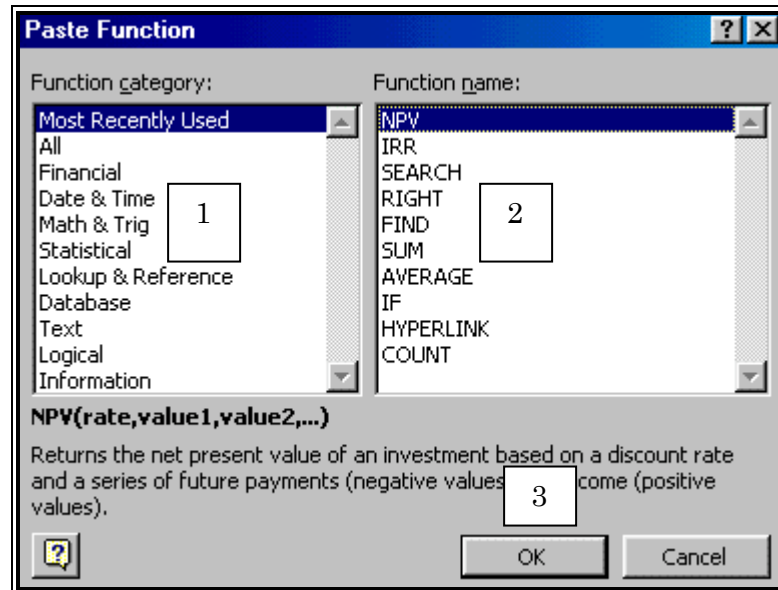
(b) click on the function icon (see Figure 42)

Figure 42: The Function icon



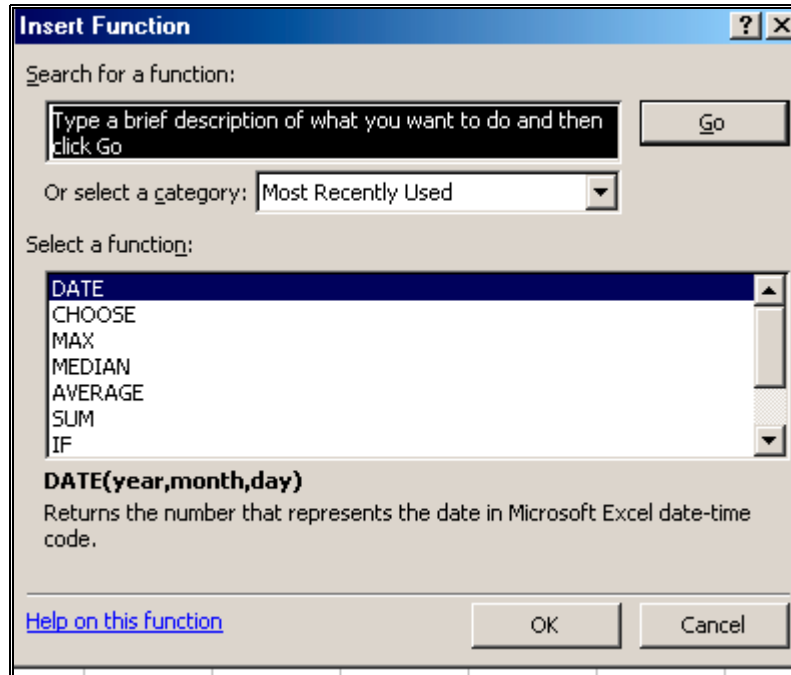
The “Paste Function” dialog (or wizard, because it is a series of dialogs) opens. The dialog is shown in Figure 43.

Figure 43: Understanding the PASTE FUNCTION dialog



The equivalent dialog in the XP version of Excel is called INSERT FUNCTION. (It is reproduced in the next figure below.) The dialog has one new feature—a “Search for a function” utility. The “Function category” is now available by clicking on the list box next to the label “Or select a category.”

Figure 44: The equivalent dialog in the XP version of Excel is called INSERT FUNCTION



This dialog has three parts:

- (1) The area “Function category” on the left half shows the labels of each group of functions. The group “Statistical” contains statistical functions like “Average” and “Variance.” The group “Math & Trig” contains algebra and trigonometry functions like “Cosine.” When you click on a category name, all the functions within the group are listed in the area “Function name.”
- (2) The area “Function name” lists all the functions within the category selected in the area “Function category.” When you click on the name of a function, its formula, and description is shown in the gray area at the bottom of the dialog.
- (3) The area with a description of the function

### Step 2 for using a function in a formula

Click on the “Function category” (in area 1 or the left half of the dialog)

that contains the function, then click on the function name in the area “Function name” (in area 2 or the left half of the dialog) and then execute the dialog by clicking on the button OK.

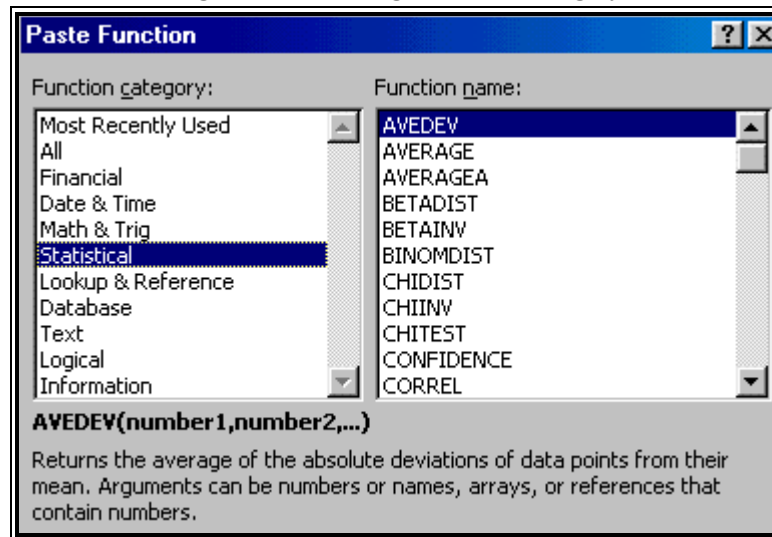
## 4.2

**A SIMPLE FUNCTION**

In my first example, I show how to select and use the function “Average” which is under the category “Statistical.”

Choose the category “Statistical” as shown in Figure 45.

Figure 45: Choosing a function category

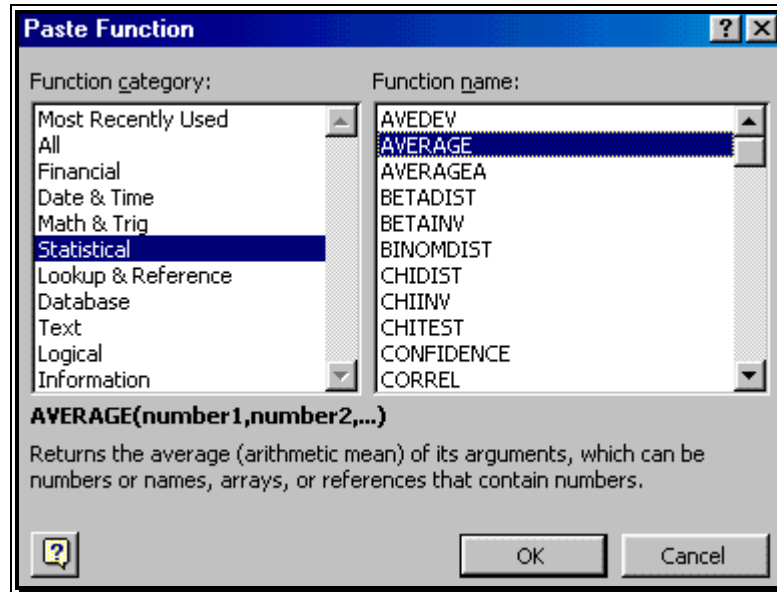


Choose the formula “Average” in the area “Function name.”

This is shown in Figure 46.

Execute the dialog by clicking on the button OK.

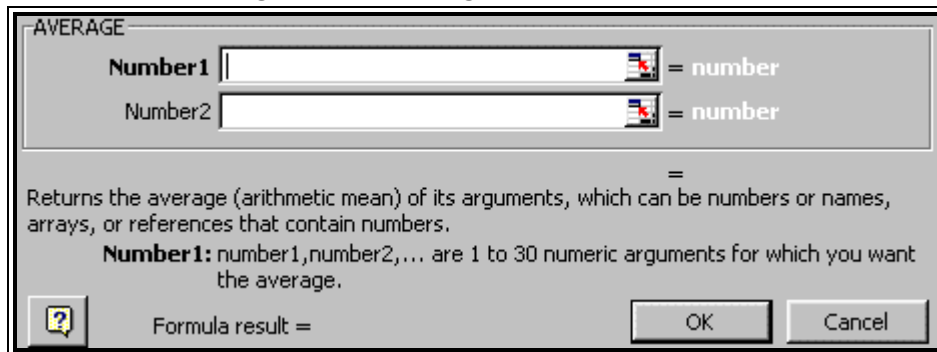
Figure 46: Choosing a function name



The dialog (user-input form) for the “Average” function opens.

For a pictorial reproduction of this, see Figure 47.

Figure 47: The dialog of the chosen function



Step 3 for inserting a function — defining the data arguments/requirements for the function

Figure 48: Selecting the cell references whose values will be the inputs into the function





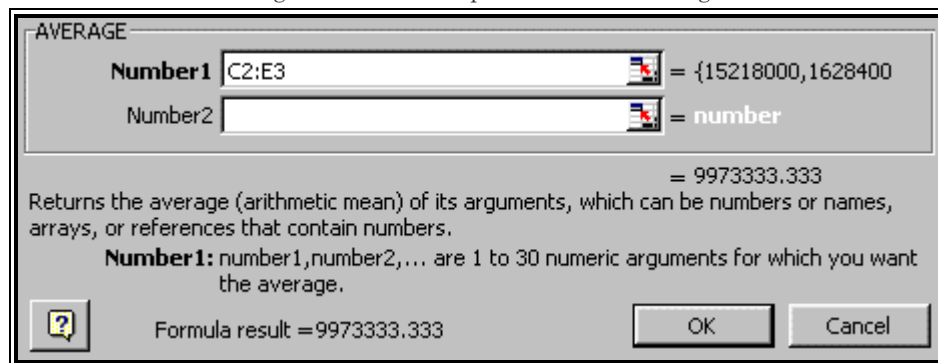
You have to tell Excel which cells contain the data to which you want to apply the function “AVERAGE.” Click on the right edge of the text-box “Number1”<sup>6</sup>. (That is, on the red–blue–and–white corner of the cell.) Go to the worksheet that has the data you want to use and highlight the range “C2 to E3.” Click on the edge of the text-box. (For a pictorial reproduction of this, see Figure 48.)

You will be taken back to the “Average” dialog. Notice that — as shown in Figure 49 — the cell reference “C2:E3” has been added.

Furthermore, note that the answer is provided at the bottom (see the line “Formula result = 9973333.333”).

Execute the dialog by clicking on the button OK.

Figure 49: The completed function dialog



<sup>6</sup> If you want to use non-adjacent ranges in the formula, then use the text-box “Number 2” for the second range. Excel will add more text-boxes once you fill all the available ones. If the label for a text-box is not in bold then it is not essential to fill that text-box. In the AVERAGE dialog shown in Figure 402, the label for the first text-box (“Number 1”) is in bold—so it has to be filled. The label for the second text-box (“Number 2”) is not in bold — so, it can be left empty.

---

The formula is written into the cell and is shown in Figure 50.

Figure 50: The function is written into the cell



```
=AVERAGE(C2:E3)
```

Press the ENTER key and the formula will be calculated.

You can work with this formula in a similar manner as a simple formula — copying and pasting, cutting and pasting, writing on multiple worksheets, etc.

If you remember the function name, you do not have to use INSERT/FUNCTION. Instead, you can simply type in the formulas using the keyboard. This method is faster but requires that you know the function.

---

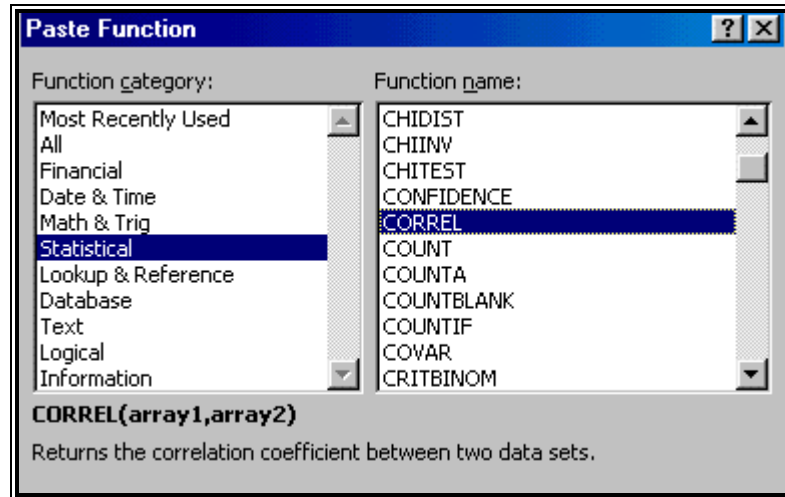
#### 4.3

### **FUNCTIONS THAT NEED MULTIPLE RANGE REFERENCES**

Some formulas need a multiple range reference. One example is the correlation formula (“CORREL”). Assume, in cell J1, you want to calculate the correlation between the data in the two ranges: “D2 to D14” and “E2 to E14.”

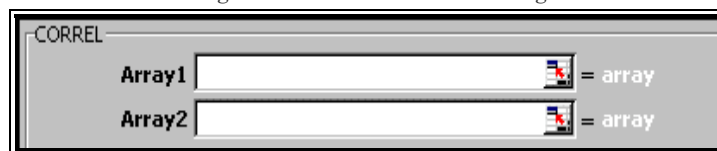
Activate cell J1. Select the option INSERT/FUNCTION. Choose the function category “Statistical.” In the list of functions that opens in the right half of the dialog, choose the function “CORREL” and execute the dialog by clicking on the button OK.

Figure 51: Choosing the function CORREL



The CORREL dialog (shown in the next figure) opens. The function needs two arrays (or series) of cells references. (Because the labels to both the text-box labels are bold, both text-boxes have to be filled for the function to be completely defined.) Therefore, the pointing to the cell references has to be done twice as shown in Figure 53 and the next two figures.

Figure 52: The CORREL dialog



### Choosing the first array/series

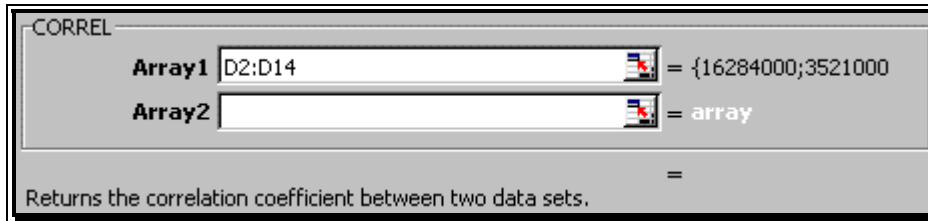
Click on the box edge of “Array1” (as shown in Figure 52.) Then go to the relevant data range (D2 to D14 in this example) and select it.

Figure 53: Selecting the first data input for the function



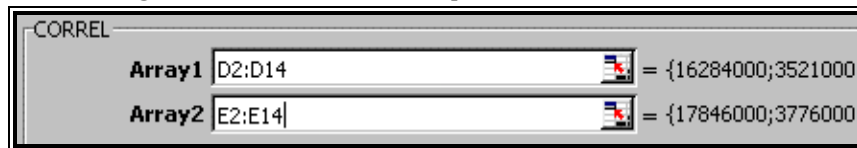
Repeat the same for “Array 2,” selecting the range “E2:E14” this time.

Figure 54: The first data input has been referenced



The formula is complete. The result is shown in the dialog in the area at the bottom “Formula result.” Execute the dialog by clicking on the button OK.

Figure 55: The second data input has also been referenced



Once the dialog closes, depress the ENTER key, and the function will be written into the cell and its result evaluated/calculated.

Figure 56: The function as written into the cell.

`=CORREL(D2:D14,E2:E14)`

#### 4.4

### WRITING A “FUNCTION WITHIN A FUNCTION”

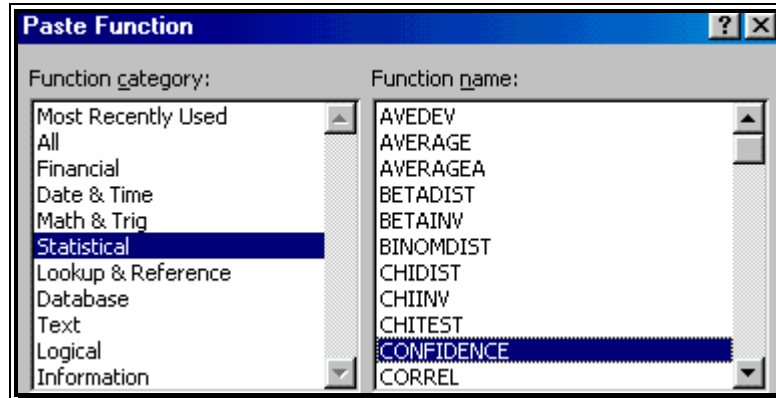
I use the example of the CONFIDENCE function from the category “Statistical.”

Choose the menu option INSERT/FUNCTION.

Choose the function category “Statistical.”

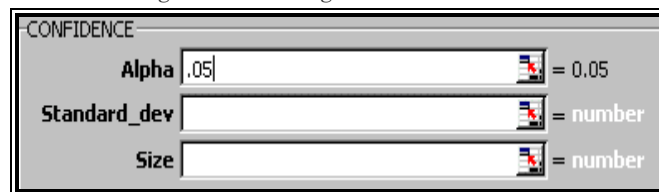
In the list of functions that opens in the right half of the dialog, choose the function CONFIDENCE and execute the dialog by clicking on the button OK.

Figure 57: Selecting the CONFIDENCE function



The Confidence dialog (user-input form) requires<sup>7</sup> three parameters: the alpha, standard deviation, and sample size. First type in the alpha desired as shown in Figure 58. (An alpha of “.05” corresponds to a 95% confidence level while an alpha value of “:.1” corresponds to a confidence interval of 90 %.)

Figure 58: Dialog for CONFIDENCE



<sup>7</sup> We know that all three are necessary because their labels are in bold.

Press the OK button.

Figure 59: The first part of the function



=CONFIDENCE(.05)

Type a comma after the “.05” (see Figure 60) and then go to INSERT/FUNCTION and choose the formula STDEV as shown in Figure 61.

Figure 60: Placing a comma before entering the second part



(05,)

Choose the range for which you want to calculate the STDEV (for example, the range “E:E”) and execute the dialog by clicking on the button OK.

Figure 61: Using STDEV function for the second part of the function



STDEV

Number1 E:E = E:E

Number2 = number

The formula now becomes:

Figure 62: A function within a function



=CONFIDENCE(.05, STDEV(E:E))

The main formula is still CONFIDENCE. The formula STDEV provides one of the parameters for this main formula. The STDEV function is nested within the CONFIDENCE function.

Type a comma, and then go to INSERT/FUNCTION and choose the function “Count” from the function category “Statistical” to get the final formula.

Figure 63: The completed formula

=CONFIDENCE(0.05,STDEV(E:E),COUNT(E:E))

There are two other ways to write this formula.

Select the option INSERT/FUNCTION, choose the function CONFIDENCE from the category “Statistical” and type in the formulae “STDEV(E:E)” and “COUNT(E:E)” as shown in Figure 64.

This method is much faster but requires that you know the function names STDEV and COUNT.

Figure 64: If sub-functions are required in the formula of a function, the sub-functions may be typed into the relevant text-box of the function’s dialog

CONFIDENCE		
Alpha	.05	= 0.05
Standard_dev	stdev(E:E)	= 10353405
Size	count(E:E)	= 235

The third way to write the formula is to type it in. This is the fastest method.

Figure 65: The result is the same

=CONFIDENCE(0.05,STDEV(E:E),COUNT(E:E))

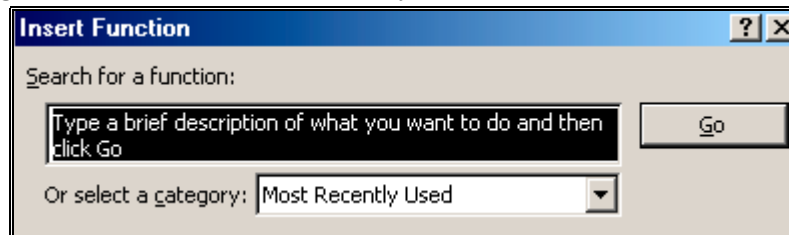
4.5

## NEW FUNCTION-RELATED FEATURES IN THE XP VERSION OF EXCEL

### Searching for a function

Type a question (like “estimate maximum value”) into the box “Search for a function” utility and click on the button “Go.” Excel will display a list of functions related to your query.

Figure 66: Search for a function utility is available in the XP version of Excel

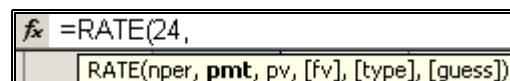


4.5.A

### ENHANCED FORMULA BAR

After you enter a number or cell reference for the first function “argument” (or first “requirement”) and type in a comma, Excel automatically converts to bold format the next argument/requirement. In the example shown in the next figure, Excel makes bold the font for the argument placeholder *pmt* after you have entered a value for *nper* and a comma.

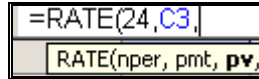
Figure 67: The Formula Bar Assistant is visible below the Formula Bar



Similarly, the argument/requirement after *pmt* has a bold font after you have entered a value or reference for the argument *pmt*

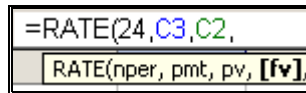


Figure 68: The next “expected” argument/requirement if highlighted using a bold font



The square brackets around the argument/requirement “fv” indicate that the argument is optional. You need not enter a value or reference for the argument.

Figure 69: An optional argument/requirement



#### 4.5.B

### ERROR CHECKING AND DEBUGGING

The basics of this topic are taught in the next chapter. Advanced features are in *Volume 3: Excel—Beyond the basics*.



## **CHAPTER 5**

# TRACING CELL REFERENCES & DEBUGGING FORMULA ERRORS

**This short chapter demonstrates the following topics:**

- TRACING THE CELL REFERENCES USED IN A FORMULA
- TRACING THE FORMULAS IN WHICH A PARTICULAR CELL IS REFERENCED
- WATCH WINDOW
- ERROR CHECKING
- FORMULA EVALUATION

---

5.1

### **TRACING THE CELL REFERENCES USED IN A FORMULA**

Click on the cell that contains the formula whose references need to be visually traced. Pick the menu option **TOOLS/AUDITING/TRACE PRECEDENTS**. (For a pictorial reproduction of this, see Figure 70.)

Figure 70: Tracing precedents. These options are from Excel versions prior to Excel XP.

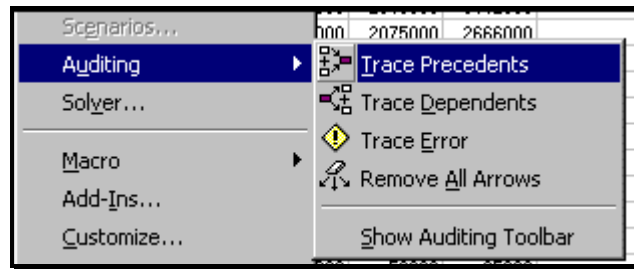
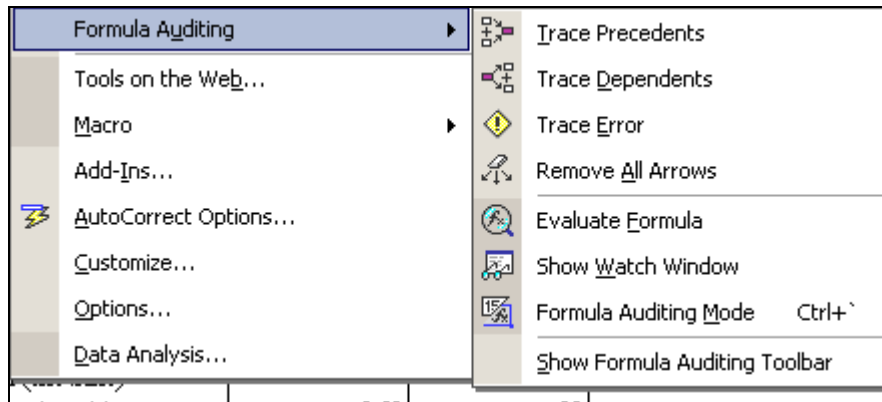


Figure 71: Excel XP offers several error-checking and debugging tools.



As shown in Figure 72, blue arrows will trace the references.

If a group of cells is referenced, then the group will be marked by a blue rectangle. The two rectangular areas are referenced in the formula.

In *Volume 3: Excel- Beyond The Basics*, you are taught the simple process through which you can select all the cells whose formulas are *precedents* of the active cell.

Figure 72: The arrows define and trace all the cells/ranges referenced in the active cell

3195000	3521000	3776000
2718000	4.18E+08	3577000
2366000	2699000	3488000
2096000	2348000	3142000
1562000	2075000	2666000
1302000	1543000	2309000
968000	1282000	2030000
674000	946000	1494000
635000	650000	1217000
571000	597000	867000
1006000	1194000	1505000
28109000	31599000	38636000
234000	254000	261000
45000	52000	65000
36000	46000	59000
47000	39000	56000
62000	49000	51000
63000	63000	43000
48000	64000	51000
29000	47000	64000
16000	28000	62000

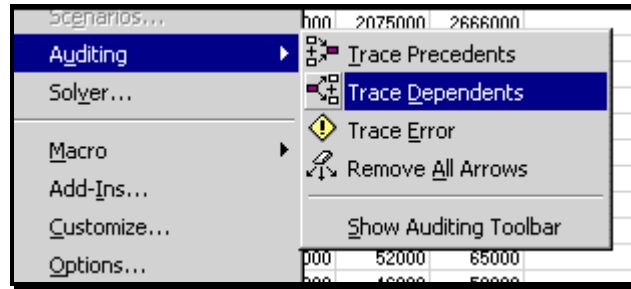
## 5.2

## TRACING THE FORMULAS IN WHICH A PARTICULAR CELL IS REFERENCED

You may want to do the opposite— see which formulas reference a particular cell.

- First, click on the cell of interest.
- Then, pick the menu option **TOOLS/AUDITING/TRACE DEPENDENTS** as shown in Figure 73. Now the arrows will go from the active cell to all the cells that have formulas that use the active cell.

Figure 73: Tracing Dependents. These options are from Excel versions prior to Excel XP.



Remove all the auditing arrows by following the menu path  
TOOLS/AUDITING/REMOVE ALL ARROWS.

In Volume 3: Excel- Beyond The Basics you learn the simple process through which you can select all the cells whose formulas are dependents of the active cell.

## 5.3

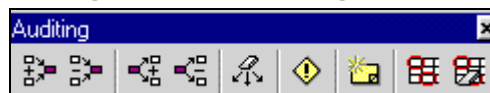
## THE AUDITING TOOLBAR

The “Auditing” toolbar opens automatically when you are using the auditing option (TOOLS/AUDITING) to review formula references.

Refer to *Volume 3: Excel- Beyond The Basics* for details on using toolbars.

In the XP version of Excel, you can launch the toolbar through the menu option TOOLS/AUDITING/SHOW FORMULA AUDITING TOOLBAR.

Figure 74: The “Auditing” toolbar



## 5.4

## WATCH WINDOW (ONLY AVAILABLE IN THE XP VERSION OF EXCEL)

The window is accessed through the menu path **TOOLS/ AUDITING/ SHOW WATCH WINDOW**, or **VIEW/ TOOLBARS/ WATCH WINDOW**.

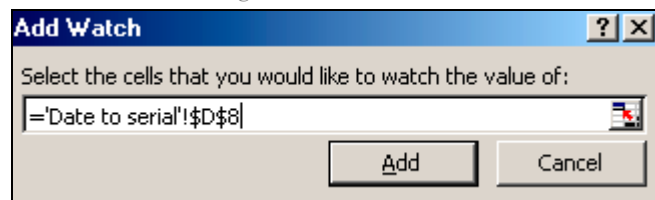
Figure 75: The Watch Window may not display correctly. Use the mouse to drag the walls of the dialog to a workable size.



Add one cell on whose values you want to keep tabs.

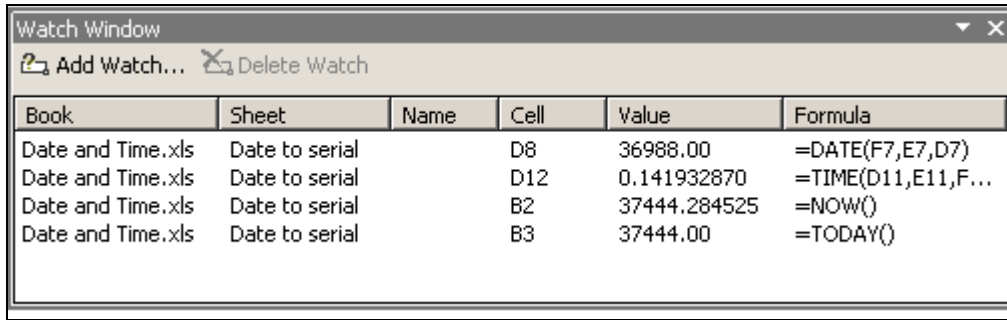
The value will be shown in the Watch Window so that you can see the value even if you are working on cells or sheets that are far from the cell whose value is being “watched.”

Figure 76: Add Watch



You can add many cells to the Watch Window. Note that the Watch Window provides precise information on the location of the cell being watched and the formula in the cell. For example, the first watched cell is on cell D8 in sheet “Date to serial” in the file “Date and Time.xls.” The formula in the cell is “=DATE(F7, E7, D7)”.

Figure 77: You can add many cells to the Watch Window



Book	Sheet	Name	Cell	Value	Formula
Date and Time.xls	Date to serial		D8	36988.00	=DATE(F7,E7,D7)
Date and Time.xls	Date to serial		D12	0.141932870	=TIME(D11,E11,F...
Date and Time.xls	Date to serial		B2	37444.284525	=NOW()
Date and Time.xls	Date to serial		B3	37444.00	=TODAY()

## 5.5

## ERROR CHECKING AND FORMULA EVALUATOR (ONLY AVAILABLE IN THE XP VERSION OF EXCEL)

The tools are accessed through TOOLS/ERROR CHECKING and TOOLS/FORMULA AUDITING/EVALUATE FORMULA.

The Error Checking dialog shows the formula in the cell as well as the type of error. In this example, these are “=DEGREE(COS(C6))” and “Invalid Name Error,” respectively.

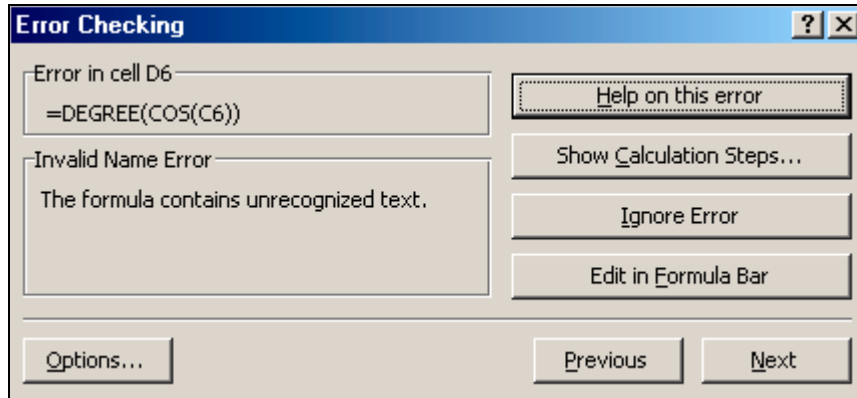
The button (“Help on this error”) links to a help file containing assistance on understanding and debugging the error.

The button “Show Calculation Steps” links to a step-by-step debugger that assists in catching the calculation step at which the error occurred.

This debugger has the same functionality as the Formula Auditor (accessed through TOOLS/FORMULA AUDITING/EVALUATE FORMULA).



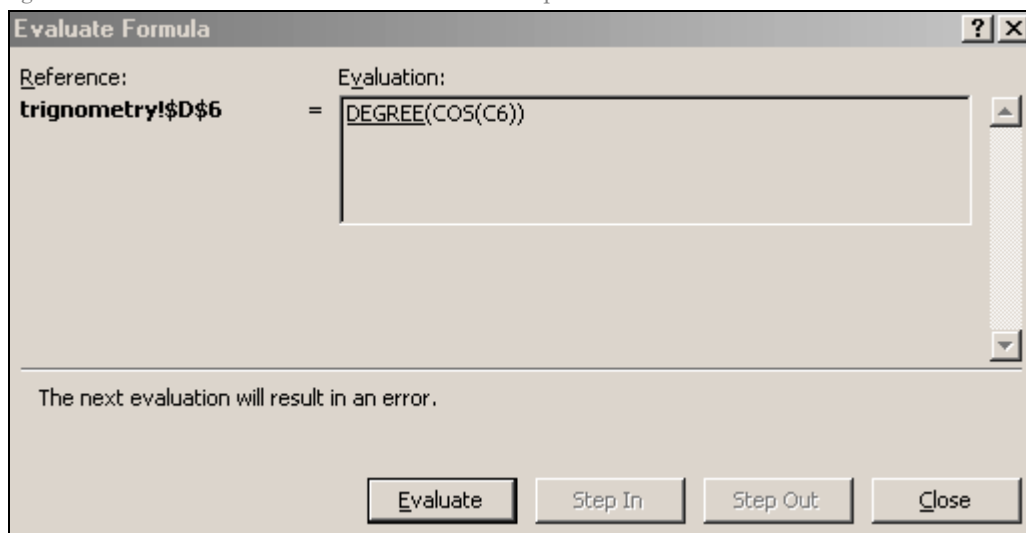
Figure 78: The Error Checking dialog shows the formula in the cell as well as the type of error



The button “Ignore Error” keeps the error “as is.” The button Options opens the dialog for setting error-checking options. The choices within the dialog are listed in section 5.8.

The Formula Evaluator shows the step at which the first calculation error occurred. This helps in identifying the primary problem. In this example, no error has occurred in the formula part “COS(C6)”. The dialog informs you that “The next evaluation (that is, calculation step), will result in an error.”

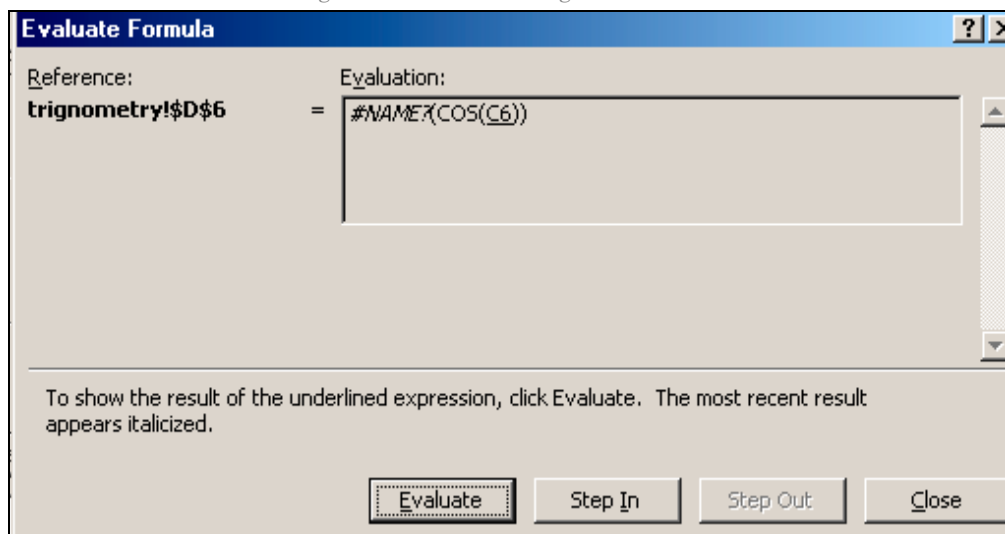
Figure 79: The Formula Evaluator shows the step at which the first calculation error occurred



After clicking on evaluate, you see that the error is in the formula part “DEGREE.” Excel also informs you of the type of error— “#NAME?” suggests that “DEGREE” does not match the name of any Excel function. (The correct function is “DEGREES.”)

The “COS“ function is nested within the DEGREE function. Clicking on “Step In” will evaluate the nested function only.

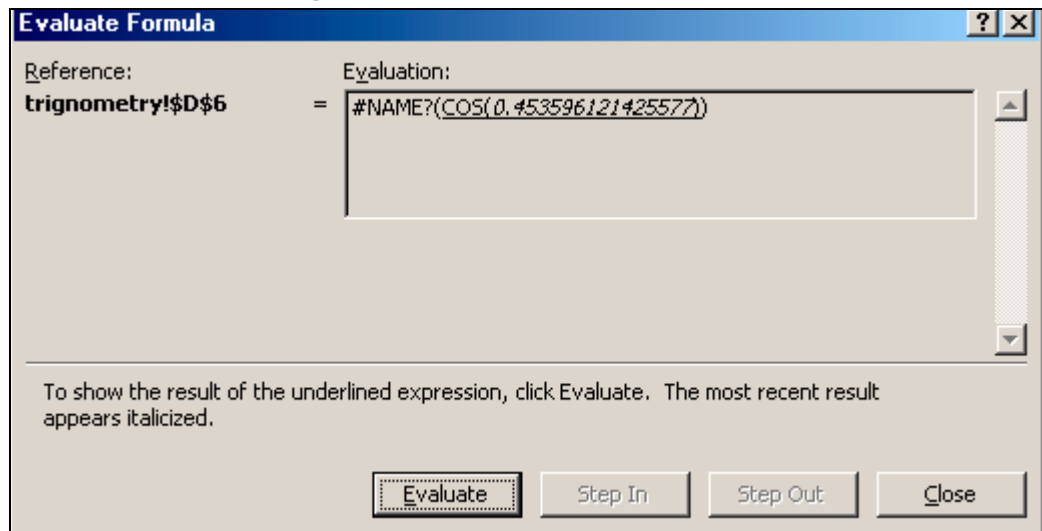
Figure 80: After clicking on evaluate...



The “COS“ function is evaluated. The function has no error.

If a function has more than two levels of nesting, then you can use the “Step Out” button to evaluate the function at the higher level of nesting.

Figure 81: The “COS” function is evaluated



5.6

## FORMULA AUDITING MODE (ONLY AVAILABLE IN THE XP VERSION OF EXCEL)

This feature is accessed through TOOLS/FORMULA AUDITING/FORMULA AUDITING MODE. After this mode is selected, when you select a cell that has or is referenced by a formula, Excel highlights the other referenced/referencing cells.

In addition, you have quick access (via the “Formula Auditing” toolbar) to all the Auditing tools discussed earlier in this chapter.

Figure 82: Formula Auditing Mode

10	<b>Hyperbolic Functions</b>	2	Number
11	COSH	Real Number	=COSH(B10)
12	SINH	Real Number	=SINH(A11)
13	TANH		=TANH(B10)
14			

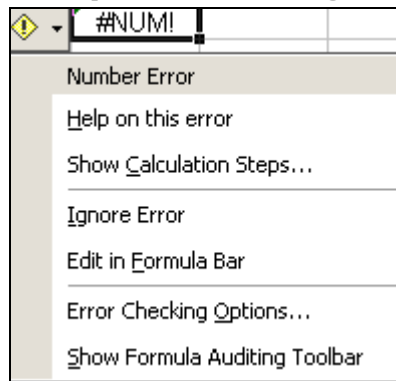
Formula Auditing toolbar:

## 5.7

**CELL-SPECIFIC ERROR CHECKING AND  
DEBUGGING**

On every cell whose value evaluates to an error value, you will see a small icon with a “!” image and a downward arrow. Click on the arrow to obtain assistance for debugging the error.

Figure 83: Cell-specific Error Checking and Debugging



In the example shown in the figure, the options show:

- the error type (“Number Error”),
- a link to assistance on understanding and debugging the error (“Help on this error”),
- a step-by-step debugger to catch the calculation step at which the error occurred (“Show Calculation Steps”),
- the option to ignore and thereby keep the error as is (“Ignore Error”),
- a link to directly edit the formula in the cell (“Edit in Formula Bar”),

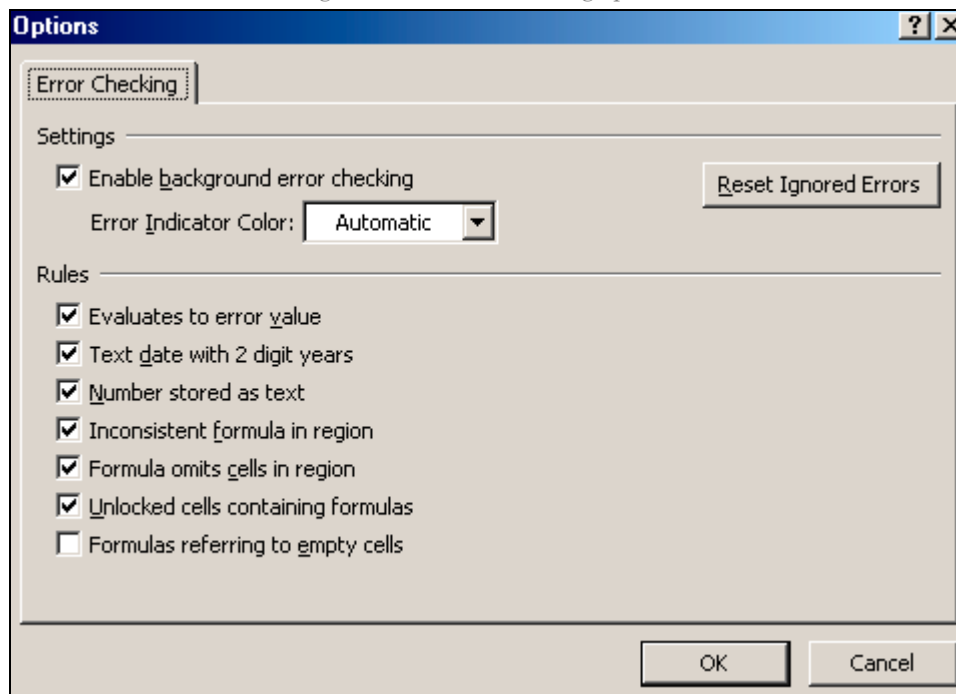
- the overall error-checking options (“Error Checking Options”), and
- direct access to the Formula Auditing Toolbar (“Show Formula Auditing Toolbar”) and, thereby, to all the features of Auditing (these features are taught in this chapter)

## 5.8

**ERROR CHECKING OPTIONS**

The Error Checking options can be assessed through **TOOLS/OPTIONS/ERROR CHECKING** or through **TOOLS/ERROR CHECKING/OPTIONS**. The dialog is reproduced in the next figure.

Figure 84: Error Checking options



You can inform Excel to show as an error any cell: that contains:

- A formula that evaluates to an error value
- A formula that refers to an empty cell
- A formula that is not consistent with the other formulas and cell references in neighboring cells
- A two-digit year (like “02”) instead of a four-digit year (like “2002”)
- A number stored as text

The other options are beyond the scope of this book. I recommend sticking with the default settings reproduced in the next figure.



## **CHAPTER 6**

### FUNCTIONS FOR BASIC STATISTICS

This chapter discusses the following topics:

- “AVERAGED” MEASURES OF CENTRAL TENDENCY
- AVERAGE, TRIMMED MEAN, HARMONIC MEAN, GEOMETRIC MEAN
- LOCATION MEASURES OF CENTRAL TENDENCY
- MEDIAN, MODE
- OTHER LOCATION PARAMETERS
- QUARTILE, PERCENTILE
- MAXIMUM VALUE, MINIMUM VALUE, LARGE, SMALL
- RANK OR RELATIVE STANDING OF EACH CELL WITHIN THE RANGE OF A SERIES
- MEASURES OF DISPERSION (STANDARD DEVIATION & VARIANCE)
- STDEV, VAR, STDEVA, VARA, STDEVP, VARP, STDEVPA, VARPA
- SHAPE ATTRIBUTES OF THE DENSITY FUNCTION
- SKEWNESS, KURTOSIS
- FUNCTIONS ENDING WITH AN “A” SUFFIX

I am presuming that the reader is familiar with basic statistical functions and/or has access to a basic statistics reference for learning more about



each function.

## 6.1

**“AVERAGED” MEASURES OF CENTRAL TENDENCY**

This set of functions perform some type of averaging to measure a “mean” value. You may want to use the Trimmed Mean function to estimate an average that excludes the extreme values of the data series. The Harmonic Mean estimates the averages of the reciprocals of the numbers in the series. The Geometric Mean is used to average rates of change.

Samples will be available at <http://www.vjbooks.net/excel/samples.htm>.

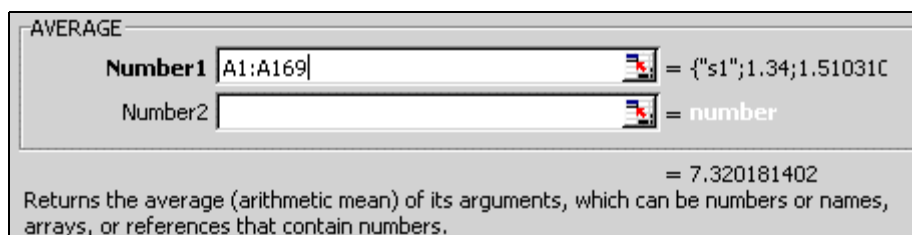
## 6.1.A

**AVERAGE**

The function calculates the simple arithmetic average of all cells in the chosen range.

*Menu path to function:* Go to the menu option INSERT/FUNCTION and choose the formula “AVERAGE the function category STATISTICAL.

Figure 85: AVERAGE function



---

*Data requirements:* The X values can be input as references to one or more ranges that may be non-adjacent. The second range can be referenced in the first text-box “Number1” after placing a comma after the first range, or it could be referenced in the second text-box “Number2.” If you use the second text-box, then a third text-box “Number3” will automatically open. (As you fill the last visible box, another box opens until the maximum number of boxes — 30 — is reached.)

The function does not count invalid cell values when counting the number of X values. The X values can take any real number value.

6.1.B

**TRIMMEAN (“TRIMMED MEAN”)**

This function is a variation of the average or mean. This function calculates the average for a set of X values after removing “extreme values” from the set. The excluded cells are chosen by the user based on the extremity (from mean/median) of the values in the range.

TRIMMEAN calculates the mean taken by excluding a percentage of data points from the top and bottom tails of a data set. The user decides on the percentage of extreme values to drop. For symmetry, TRIMMEAN excludes a set of values from the top and bottom of the data set before moving on to the next exclusion.

*Menu path to function:* INSERT/FUNCTION/STATISTICAL/TRIMMEAN.

*Data requirements:* The X values can be input as references to one or more ranges that may be non-adjacent. The function does not count invalid cell values when counting the number of X values. The X values can take any real number value.

Figure 86: TRIMMEAN (Trimmed Mean)

TRIMMEAN	
Array	A:A = A:A
Percent	.05 = 0.05
= 7.127690472	

In the dialog (shown above), *Percent* is the fractional number of data points to exclude from the calculation. Percent must be greater than zero and less than one.

## 6.1.C

**HARMEAN (“HARMONIC MEAN”)**

The function calculates the harmonic mean of all cells in the chosen range(s). The harmonic mean is the reciprocal of the arithmetic mean of reciprocals. In the formula below, H is the harmonic mean, n the sample/range size and the Y's are individual data values.

*Menu path to function:* INSERT/FUNCTION/STATISTICAL/HARMEAN.

Figure 87: HARMEAN (Harmonic Mean)

HARMEAN	
Number1	A1:A169 = {"s1";1.34;1.51031C
Number2	= number
= 3.84416703	
Returns the harmonic mean of a data set of positive numbers: the reciprocal of the arithmetic mean of reciprocals.	

*Data requirements:* The X values can take any real number value except zero.

Table 10: Comparing the results of the functions Average, Trimmed Mean and Harmonic Mean

Function	s1	s2	x1	x2	x3	x4
Average/mean	7.32	7.23	1173.00	14.55	0.17	1158.45
Trimmed Mean	7.13	7.00	1173.00	14.42	0.02	1158.71
Harmonic Mean	3.84	3.18	120.17	13.52	0.01	#NUM!

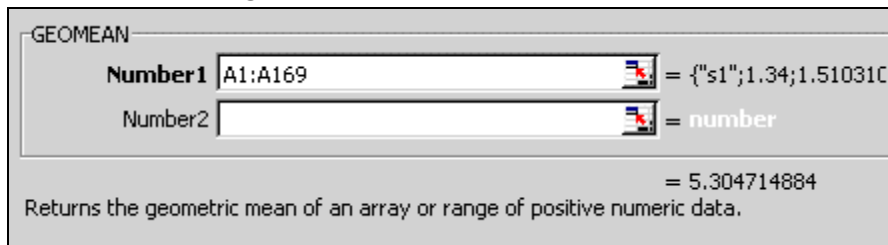
Harmonic mean for x4 is zero because one value of x4 is not positive.

6.1.D **GEOMEAN (“GEOMETRIC MEAN”)**

This function is typically used to calculate average growth rate given compound interest with series rates. In general, the function is good for estimating average growth or interest rates.

*Menu path to function:* INSERT/ FUNCTION/ STATISTICAL/ GEOMEAN. *Data requirements:* All values should be positive.

Figure 88: GEOMEAN (Geometric Mean)



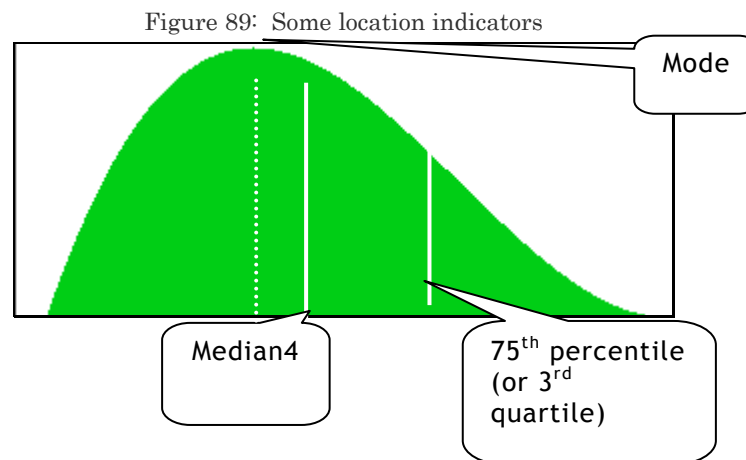
## 6.2

**LOCATION MEASURES OF CENTRAL TENDENCY  
(MODE, MEDIAN)**

The Median and — less often — the Mode are also used for estimating the central tendency of a series. The Median is much better in situations where, either:

- (a) A few extreme highs or lows are influencing the Mean (note that the TRIMMEAN or Trimmed Mean function shown in the previous section can reduce the chance of extreme values over-influencing a Mean estimate), or
- (b) The central tendency is required to obtain the mid-point of observed values of the data series as in the “Median Voter” models, which are used to know if the “Median Voter” threshold is crossed in support of a point on the nominee’s agenda. (In a two-person face-off, any more than the Median vote will result in a greater than 50% majority).

Samples will be available at <http://www.vjbooks.net/excel/samples.htm>.



6.2.A                    **MEDIAN**

The Median is the number in the middle of a set of numbers. It is the 50<sup>th</sup> percentile.

*Menu path to function:* INSERT/FUNCTION/STATISTICAL/MEDIAN.

*Data requirements:* Any array/range with real numbers.

6.2.B                    **MODE**

This function returns the most frequently occurring value in a range.

*Menu path to function:* INSERT/FUNCTION/STATISTICAL/MODE.

*Data requirements:* Any array/range with real numbers. The range has to contain duplicate data values.

---

6.3                                    **OTHER LOCATION PARAMETERS (MAXIMUM, PERCENTILES, QUANTILES, OTHER)**

Other useful location indicators for key points in a series are the quartiles, percentiles, maximum value, minimum value, the Kth largest value, and the rank.

Samples will be available at <http://www.vjbooks.net/excel/samples.htm>.

6.3.A

**QUARTILE**

This function calculates a quartile of a data series.

**QUARTILE (Data, Quartile)**

Choose the quartile you desire to obtain. The five quartiles are shown in the next table.

Table 11: Choosing the Quartile

<i>Quartile value of...</i>	<i>Calculates the...</i>
0	0.0....1% ile
1	First quartile (25th percentile)
2	Median value (50th percentile)
3	Third quartile (75th percentile)
4	Fourth quartile (99.9x%ile)

*Menu path to function:* INSERT/FUNCTION/STATISTICAL/QUARTILE.

*Data requirements:* Any array/range with real numbers. Note: the data series has to contain between 1 and 8,191 data points

6.3.B

**PERCENTILE**

This function returns the P<sup>th</sup> percentile of values in a data series. You can use this function to establish a threshold of acceptance. For example, you can prefer to examine candidates who score above the 95th percentile will qualify for a scholarship.

*Menu path to function:*

INSERT/FUNCTION/STATISTICAL/PERCENTILE.

Figure 90: Estimating the 5th percentile. K is the percentile value in the range 0 to 1.

PERCENTILE		
Array	A:A	= A:A
K	.05	= 0.05
		= 1.510310696
Returns the k-th percentile of values in a range.		

*Data requirements:* Any array/range with real numbers. If the data array is empty or contains more than 8,191 data points, PERCENTILE returns the” #NUM!” error value. If K is not a multiple of  $(1/(n - 1))$ , then Excel interpolates the value at the Kth percentile.

Figure 91: Estimating the 95th percentile

PERCENTILE		
Array	A:A	= A:A
K	0.95	= 0.95
		= 18.6319279
Returns the k-th percentile of values in a range.		

6.3.C

### MAXIMUM, MINIMUM AND “KTH LARGEST”

#### MAX (“Maximum value”)

MAX and MAXA: The functions calculate the largest value in a series.



---

*Menu path to function:* STATISTICAL/MAX , & STATISTICAL/MAXA.

*Data Requirements:* Any array/range with real numbers. In addition, MAXA may include “True,” “False,” or numbers in text format

---

## MIN (“Minimum value”)

MIN and MINA: The functions calculate the smallest value in a series

*Menu path to function:* STATISTICAL/MIN, & STATISTICAL/MINA

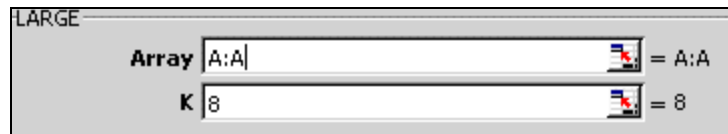
*Data Requirements:* Any array/range with real numbers. In addition, MINA include “True,” “False,” or numbers in text format

---

## LARGE

This function calculates the K<sup>th</sup> largest value in a range.

Figure 92: LARGE



*Menu path to function:* STATISTICAL/LARGE

*Data Requirements:* Any real number.

**SMALL**

This function calculates the Kth smallest value in a range.

*Menu path to function:* STATISTICAL/SMALL

*Data Requirements:* Any real number.

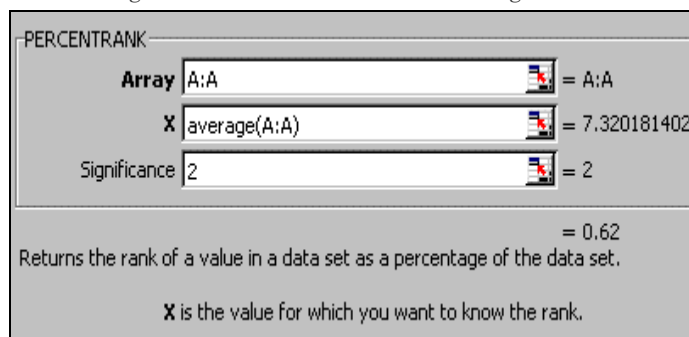
6.3.D

### **RANK OR RELATIVE STANDING OF EACH CELL WITHIN THE RANGE OF A SERIES**

**PERCENTRANK**

The PERCENTRANK function returns the rank of a value in a data set as a percentage of the data set. The function can be used to evaluate the relative standing of a value within a data set. For example, you can use PERCENTRANK to evaluate the standing of a test score among all scores for the test.

Figure 93: Percentrank of the average/mean



*Menu path to function:* INSERT/FUNCTION / STATISTICAL / PERCENTRANK.

---

*Data requirements:* Any array/range with real numbers.

---

## RANK

The function RANK calculates the relative rank of a value within a series of numbers data. You can choose to obtain the ranks on the basis of ascending or descending values. X is the data point whose rank is desired within the range. Order sets the sorting direction— 1 for ascending ranking, 0 or blank for descending ranking. Cells with the same value cells are given the same rank.

*Menu path to function:* INSERT / FUNCTION / STATISTICAL / RANK.

*Data requirements:* Any array/range with real numbers.

---

## 6.4

### MEASURES OF DISPERSION (STANDARD DEVIATION & VARIANCE)

Table 12: Standard Deviation & Variance.

<i>Function</i>	<i>Description</i>	<i>Location within INSERT / FUNCTION</i>	<i>Data Requirements</i>
Sample dispersion: STDEV, VAR	The functions STDEV and VAR estimate the sample standard deviation and variance, respectively. VAR is the square of STDEV.	STATISTICAL / STDEVA & STATISTICAL / VARA	Any range with sufficient number of numeric data points. Text and logical values are excluded.
STDEVA, VARA	These are variants of the functions above but	STATISTICAL /	Text and logical values such as TRUE and

<i>Function</i>	<i>Description</i>	<i>Location within INSERT / FUNCTION</i>	<i>Data Requirements</i>
	with a wider range of acceptable data types as input data.	STDEVA & STATISTICAL / VARA	FALSE are included in the calculation. TRUE is valued as 1; text or FALSE is valued as 0.
Population dispersion: STDEVP, VARP	The less often used population dispersion functions are sometimes also used for large sample sizes. STDEVP assumes that its data are the entire population. Typically, you use the sample formulae. For large sample sizes, STDEV and STDEVP return approximately equal values. VARP is square of STDEVP	STATISTICAL / STDEVA & STATISTICAL / VARA	A large number of observations.  Text and logical values are excluded.
STDEVPA, VARPA	These are variants of the functions above but with a wider range of acceptable data types as input data	STATISTICAL / STDEVA & STATISTICAL / VARA	Text and logical values such as TRUE and FALSE are included in the calculation. TRUE is valued as 1; text or FALSE is valued as 0. Text and logical values such as TRUE and FALSE are included in the calculation. TRUE is valued as 1; text or FALSE is valued as 0.

Figure 94: Dialog for STDEV

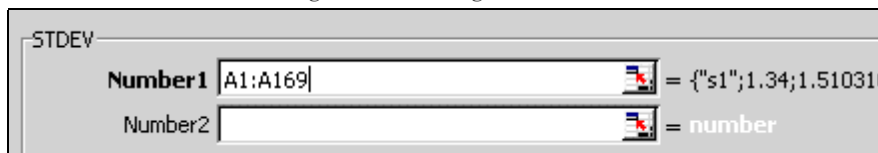
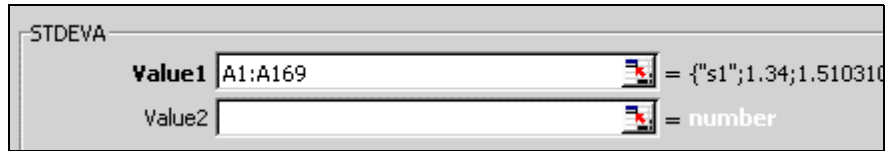


Figure 95: Dialog for STDEVA. Note that the functions with the “A” suffix request “Values” as input while the equivalent non-suffixed functions request “Numbers”



## 6.5

## SHAPE ATTRIBUTES OF THE DENSITY FUNCTION (SKEWNESS, KURTOSIS)

## 6.5.A

### SKEWNESS

Skewness measures asymmetry around the mean. The parameter is best interpreted as relative to the Normal Density Function (whose Skewness equals zero). The interpretation of the Skewness for a series (relative to the Normal Density Function) is:

- Skewness  $> 0$   $\rightarrow$  asymmetric tail with more values above the mean.
- Skewness  $< 0$   $\rightarrow$  asymmetric tail with more values below the mean.

The next three figures shown Density Functions that have a Skewness  $> 0$ ,  $= 0$ , and  $< 0$ , respectively, for three variables Y1, Y2 and Y3. (Y2 is distributed Normally).

Figure 96: Distribution of series Y1.  
Skewness > 0

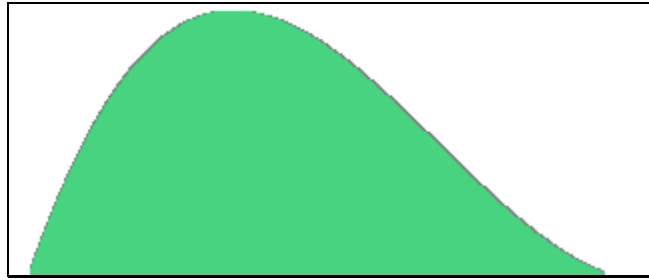


Figure 97: Distribution of series Y2.  
Skewness = 0.

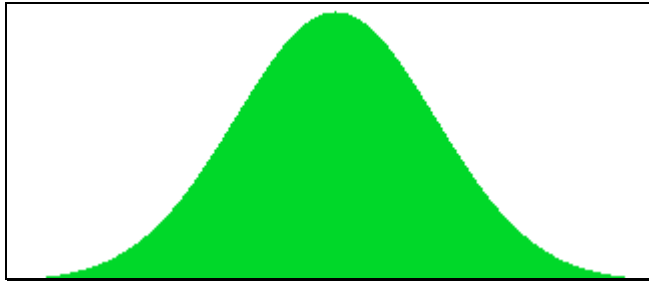
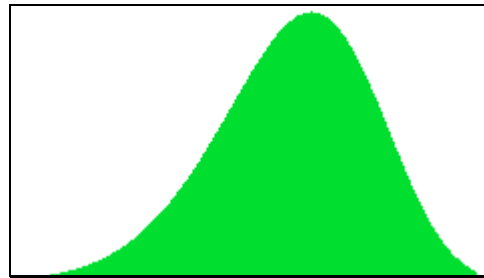
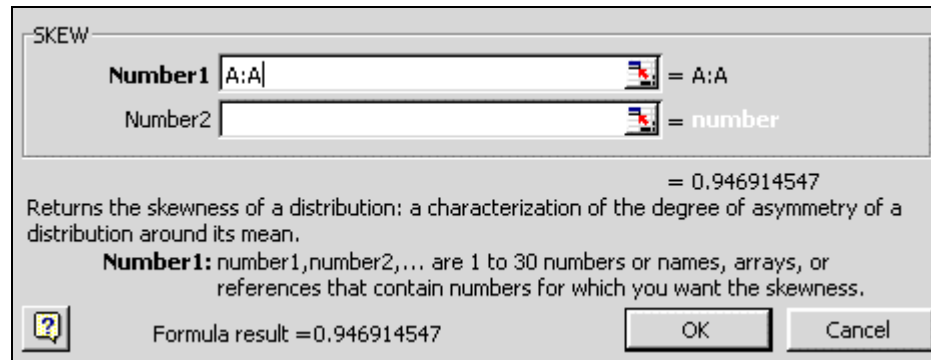


Figure 98: Distribution of series Y3.  
Skewness < 0



Samples will be available at <http://www.vjbooks.net/excel/samples.htm>.

Figure 99: SKEW (Skewness)



*Menu path to function:* INSERT / FUNCTION / STATISTICAL / SKEW

## 6.5.B

**KURTOSIS**

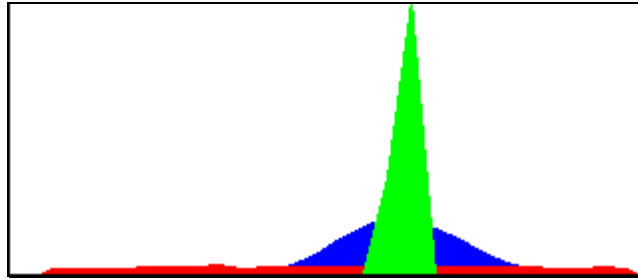
Compared with the Normal Density Function (which has a Kurtosis of zero), the interpretation of the kurtosis for a series is:

- Kurtosis  $> 0$   $\rightarrow$  peaked relative to the Normal Density Function
- Kurtosis  $< 0$   $\rightarrow$  flat relative to the Normal Density Function

The next figure shows three Density Functions. The Density Functions lie around the same Mean and Median, but note the difference in the relative flatness of the Density Functions:

Distribution of series X1 is the flattest with a Kurtosis  $< 0$ , that of X2 is less flat with a Kurtosis  $= 0$  (a Normal Density Function) and that of series X3 is the least flat with a Kurtosis  $> 0$ .

Figure 100: Example of Density Functions with different Skewness



Samples will be available at <http://www.vjbooks.net/excel/samples.htm>.

*Menu path to function:* INSERT / FUNCTION / STATISTICAL / KURT

## 6.6

**FUNCTIONS ENDING WITH AN “A” SUFFIX**

These functions calculate the same statistic as their “twin” formula (the one without the prefix “A”) but include a wider range of valid cell values in the relevant formula. The “A” –suffixed functions include the following types of cell values:

- Logical (and not numeric) like “True” and “False” (valued as 1 and 0, respectively),
- Blank cells (valued as 0), and
- Text (valued as 0).

A text string or a blank cell is valued as zero. The next table lists these twin functions:



Table 13: Functions ending with the “A” suffix.

<i>The non-prefixed function</i>	<i>The “A” prefixed “twin” formula</i>	<i>Comment</i>
AVERAGE	AVERAGEA	Simple average/mean
COUNT	COUNTA	Count of valid cells. The prefixed function is very useful in counting.
STDEV	STDEVA	Standard deviation
STDEVP	STDEVPA	Standard deviation from a population or a very large sample (relative to population)
VAR	VARA	Variance
VARP	VARPA	Variance from population (and not sample) data, or from a very large sample (relative to population)
MIN	MINA	Minimum value
MAX	MAXA	Maximum value





## **CHAPTER 7**

# PROBABILITY DENSITY FUNCTIONS AND CONFIDENCE INTERVALS

This chapter teaches the following topics

- PROBABILITY DENSITY FUNCTION (PDF)
- CUMULATIVE DENSITY FUNCTION (CDF)
- THE CDF AND CONFIDENCE INTERVALS
- INVERSE MAPPING FUNCTIONS
- NORMAL DENSITY FUNCTION
- STANDARD NORMAL OR Z-DENSITY FUNCTION
- T-DENSITY FUNCTION
- F-DENSITY FUNCTION
- CHI-SQUARE DENSITY FUNCTION
- OTHER CONTINUOUS DENSITY FUNCTIONS: BETA, GAMMA,  
EXPONENTIAL, POISSON, WEIBULL & FISHER
- DISCRETE PROBABILITIES— BINOMIAL, HYPERGEOMETRIC  
& NEGATIVE BINOMIAL
- LIST OF DENSITY FUNCTION FUNCTIONS — PROBABILITY  
DENSITY FUNCTION (PDF), CUMULATIVE DENSITY  
FUNCTION (CDF)
- LIST OF SELECT INVERSE FUNCTION

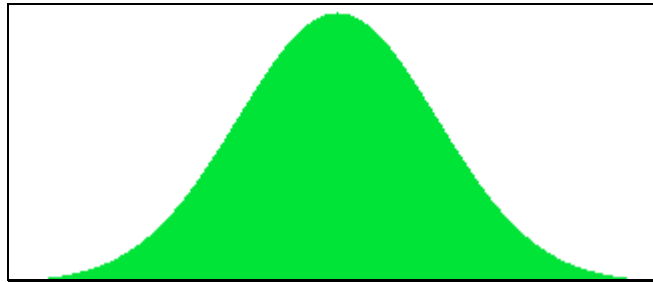
7.1

**PROBABILITY DENSITY FUNCTIONS (PDF),  
CUMULATIVE DENSITY FUNCTIONS (CDF), AND  
INVERSE FUNCTIONS**

7.1.A

**PROBABILITY DENSITY FUNCTION (PDF)**

Figure 101: Probability Density Function (PDF)



The horizontal axis contains the values of the series/series. The vertical height of the curve at a point on the X-axis shows the probability associated (or frequency) with that point. (The total area under the curve equals 1; so, all the “heights” add up to 1 or 100 %.) The higher the frequency with which that point is observed in a series/series, the higher is its frequency.

An often-used probability Density Function — the “Normal” probability Density Function — is shown in the previous figure. This Density Function has some convenient properties:

- its Mean, Mode and Median are the same
- it does not have a left or right skew, and
- the left half is a mirror image of the right half.

All these “symmetrical” properties allow one to draw inferences from tests run on series that are distributed “Normally.”

---

Based on several theorems, postulate, “most data series start behaving more and more like a series that follows a Normal Density Function as the sample size (or number of data points) increases.” (This presumption follows from the “Central Limit Theorem.”) This has made the Normal Density Function the bedrock of most statistics and econometrics.

## 7.1.B

**CUMULATIVE DENSITY FUNCTION (CDF)**

We are typically interested in measuring the area under the curve (a) to the left of an X value (b) to the right of an X value, or (c) between two X values. The height of the curve at any X value is not so useful by itself because it does not answer any of these questions directly.

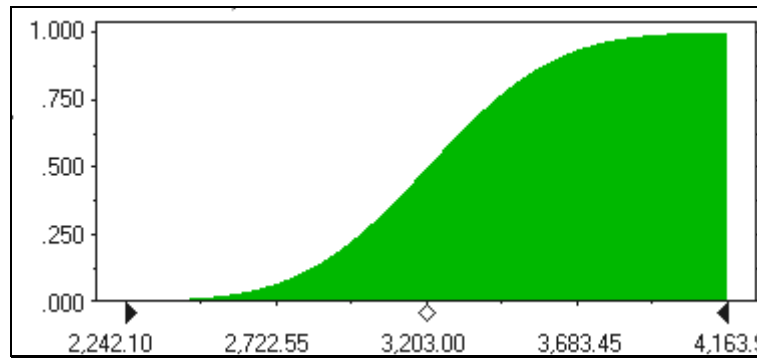
A better graphical tool to measure the “area under the curve” is the Cumulative Density Function (CDF). A CDF plots the X categories against the “probability of a value taking a value below the chosen X value.”

The CDF for the Normal Density Function is reproduced in the next figure. The curve increases from left to right (from 0 to 1<sup>8</sup>). The height at any X-value tells us “the probability of a value having a value below this X-value equals the Y-axis value of the CDF at this X.”

---

<sup>8</sup> The area under any Density Function curve always equals 1. The relative frequency equals (frequency that X takes on this particular value) divided by (the total sample size). Therefore, in a sense, the height gives the frequency weight for each X value. If you sum all the relative frequencies, their sum is “sample size divided by sample size” equals 1. This is the area under the curve. It can also be expressed in percentage terms; the total percentage area then becomes 100%.

Figure 102: The “Cumulative Density Function” (CDF) associated with the Probability Density Function (PDF) shown in the previous figure



The CDF is a better tool for answering the typical questions about the properties of a data series. CDF is of great importance for building Confidence Intervals and implementing hypothesis tests.

In fact, for some Density Functions, Excel only measures the CDF only (and not the CDF & PDF).

---

### The CDF and Confidence Intervals

The concept of a Confidence Interval for a measured parameter (typically for a mean) is based on the concept of probability depicted by a Density Function curve. A Confidence Interval of 95% is a range of X values within whose range the sum of the relative frequencies is 0.95 or 95%.

I will use this property to show how to create Confidence Intervals for various distributions using the Inverse of the CDF. (You will learn more on the Inverse in the next sub-section.)

Table 14: Probability Density Function (PDF) and Cumulative Density Function (CDF)

Function	Is there an option to request the Cumulative Density Function (CDF)?	Cumulative Density Function (CDF) & Probability Density Function (PDF): Information requirements for parameterization			
		<i>Mean</i>	<i>Std Dev</i>	<i>Degrees of freedom</i>	<i>Other</i>
TDIST				✓	Tails #
LOGNORMDIST	✓	✓	✓		
FDIST				✓	2 <sup>nd</sup> degree of freedom
BETADIST				alpha, beta, upper and lower bound	
CHIDIST				✓	
NORMDIST	✓	✓	✓		
NORMSDIST	✓				
WEIBULL					Alpha and beta
NEGBINOMDIST		(Probability)			# of successes
BINOMDIST	✓	(Probability)			
EXPONDIST	✓				Lambda
GAMMADIST	✓				Alpha and beta
HYPGEOMDIST		Sample size, population size, # of successes in population			
POISSON	✓	✓			



## 7.1.C

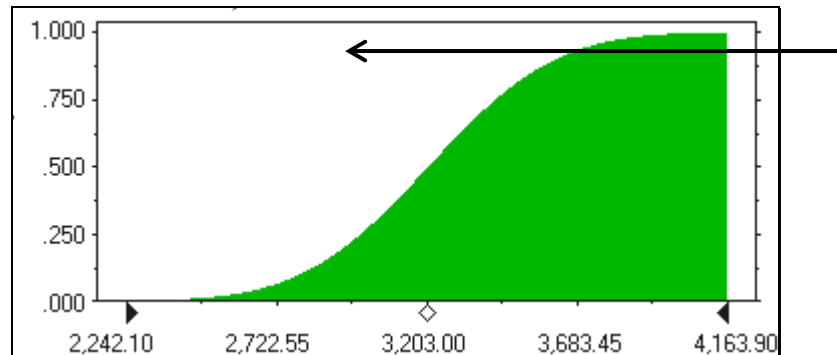
**INVERSE MAPPING FUNCTIONS**

The Cumulative Density Function (CDF) tells us “For any X series, the probability of the value of X falling below a specific x value can be calculated from the height of the Cumulative Density Function (CDF) at that x value.”

An inverse function does the reverse mapping: “For a probability  $P$ , the  $X$  to who’s left the probability of the data lying can be obtained by a reverse reading of the Cumulative Density Function (CDF). That is, from “Desired Cumulative Probability  $\rightarrow$  unknown  $X$  that will give this desired cumulative probability  $P$ .”

Alternatively, “Inverse” functions find the  $X$  value that corresponds to a certain “probability of values below the  $X$  equaling a known cumulative probability.”

Figure 103: Reading inverse mapping from a Cumulative Density Function (CDF). The arrows show the values below which are 95% of the values of the data series.



Inverse functions permit easy construction of Confidence intervals. This will be shown several times in further sections whenever I discuss the construction of Confidence intervals.

Table 15: Inverse functions (also used to create Confidence intervals). Samples will be available at <http://www.vjbooks.net/excel/samples.htm>.

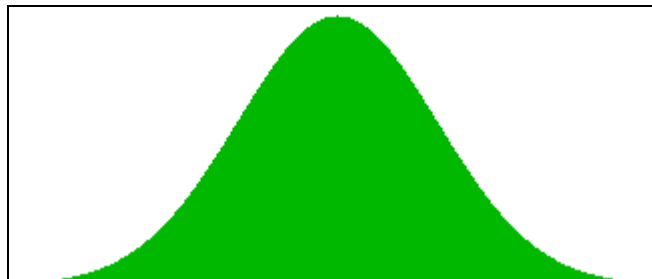
Function	Inverse Function (“probability to value”) of this Cumulative Density Function (CDF)?	Information required by all inverse functions	Other information requirements			
		Probability for which the corresponding value is sought	Mean	Std Dev	Degrees of freedom	Other
TINV	TDIST	✓			✓	
LOGINV	LOGNORMDIST	✓	✓	✓		
FINV	FDIST	✓			✓	Second degree of freedom
BETAINV	BETADIST	✓				alpha, beta, upper and lower bound
CHINV	CHIDIST	✓			✓	
NORMINV	NORMDIST	✓	✓	✓		
NORMSINV	NORMSDIST	✓				

7.2

**NORMAL DENSITY FUNCTION**

The Normal Density Function has several properties that make it easy to make generalized inferences for the attributes of a series whose Density Function can be said to be “Normal.”

Figure 104: A Normal Probability Density Function



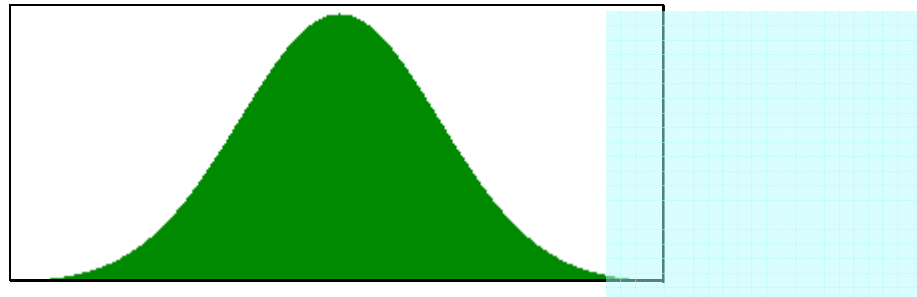
## Symmetry

The major measures of central tendency — the mean, median, and mode — all lie at the same point right at the place where the bell shaped curve is at its greatest height.

The Density Function is perfectly symmetrical around this “confluence” of central tendencies. Therefore, the left half of the Density Function (measured as all points to the left of the mode/median/mean) is a mirror image of the right half of the Density Function.

This is shown in the next figure — the lighter shaded half is a mirror image of the darker shaded half. So, the frequency of the values of the variables becomes lower (that is, the height of the curve lowers) as you move away from the mode/mean/median towards either extreme. This change is gradual and occurs at the same rate for negative and positive deviations from the mean.

Figure 105: An idealized “symmetrical” Normal Density Function. Note that the relatively lightly shaded half is a mirror image of the relatively darker shaded half



The symmetry also implies that:

- (a) The Density Function is not “skewed” to the left or right of the mode/median/mean (and, thus, the Skewness measure = 0)
- (b) The Density Function is not “too” peaked (which would imply that the

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change in probability is very rapid when moving from the mode/median/mean towards an extreme) nor “too” flat (which would imply that the change in probability is very slow when moving from the mode/median/mean towards an extreme). The first property implies that Skewness = 0, and the second implies that Kurtosis = 0.

---

### **Convenience of using the Normal Density Function**

If a series is Normally distributed, then you just need two parameters for defining the Density Function for any series X— the mean and standard deviation of the variables values! This is because, once you know the mean, you also know the mode and median (as these two statistics equal the mean for a Normal Density Function).

Once you know the standard deviation, you know the spread of values around the mean/mode/median. (A series that follows a Normal Density Function is not skewed to the left or right, nor is “too” peaked or “too” flat.)

---

### **Are all large-sample series Normally Distributed?**

Some formal mathematical theorems and proofs support the theory that “as the sample size gets larger most Density Functions become more like the Normal Density Function.” Therefore, for example, if a series has a left skewed Density Function when a sample of 20 observations is used, it may also behave more like a symmetrical (that is, a zero-skewed) Normal Density Function if the sample size is, for example, 1000 observations.

(Even if the Density Function does not have the classic bell-shape of a

normal curve, it can behave like a Normal Density Function if it satisfies — to a sufficient extent — the conditions that imply normality –

- The fact that the mode, mean and median are very close to each other
- An additional feature is that the Density Function is roughly symmetrical around the mode/median/mean.

---

### **Statistics & Econometrics: Dependence of Methodologies on the assumption of Normality**

Assuming that variables are distributed Normally is a practice that underlies— and even permits— most hypothesis testing in econometrics and statistics. Without this assumption, statistics, as we know it, would lose much of its power to estimate coefficients and establish relationships amongst variables.

Assume you have three variables — X1, X2, and X3. X1 is measured in dollars with a mean of \$2.30, X2 also in dollars with a mean of \$30,000 and X3 in tons. You assume that all the variables are distributed Normally. This permits you to make inferences about the series. Once you know the mean and standard deviation for X1, you can make statements like “60% of the values of X1 lie below \$2.62,” “Between the values \$24,000 and \$28,000, we will find that 18% of the values of X2 will lie,” or, “Over 40% of the values of X3 lie below 24 tons.” (Note: the figures are chosen arbitrarily). This is fine. But the problem is that the relation between the “mean, standard deviation, X values and probability” must be calculated anew for each of the variables because they are measured in different units (dollars versus tons) or/and on different scales and ranges (X1 versus X2 in our example).

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This limits the usefulness of using the Normal Density Function to assess the relation between series values and the probability of values occurring less than, equal to or above them. In practical terms, you would need a statistics textbook that lays out the relationship between an X value and probability for all possible combinations of mean and standard deviation!

---

### The Standard Normal and its power

Luckily, a method removes the need for such exhaustive table listings. This method involves rescaling all series that follows a Normal Density Functions to a common scale such that, on the new scale, the variables have a mean/mode/median of zero and a standard deviation of one. The process is called “standardization” and this standardized Density Function is called the standard Normal Density Function or the Z – Density Function.

The Z –scores are also used to standardize the Density Functions of the means of variables or the estimates of statistical coefficients. If the standard error of mean for the population from which the sample is unknown (as is typically the case), then the T Density Function is used instead of the Z Density Function.

7.2.A

### THE PROBABILITY DENSITY FUNCTION (PDF) AND CUMULATIVE DENSITY FUNCTION (CDF)

#### PDF:

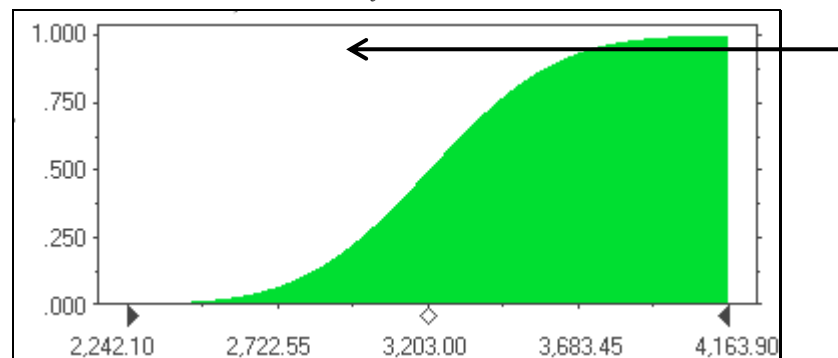
NORMDIST (x, mean, standard deviation, false) → probability of values taking the value X

#### CDF:

NORMDIST (x, mean, standard deviation, true) → probability of values lying to the left of X

Figure 106: The dialog for estimating the probability associated with a value of a point in a series that follows a Normal Density Function

Figure 107: The Cumulative Density Function (CDF) for a series that follows a Normal Density Function. The arrows show the value to the left of which lie 95% of the values in the Density Function.



The Cumulative Density Function (CDF) is the integral of the function on the right hand side in the above equation. The range of integration is negative infinity (or the population minimum) to the X value being studied.

*Menu path to function:* INSERT / FUNCTION / STATISTICAL / NORMDIST.

*Data requirements:* The data series should follow the assumed Density Function type (Normal).

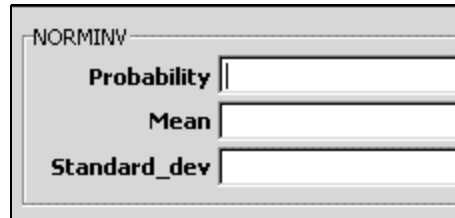
## 7.2.B

**INVERSE FUNCTION**

This function calculates the inverse of the normal cumulative Density Function for a user–specified mean and standard deviation.

NORMINV (probability below the X, MEAN, STANDARD DEVIATION) → X

Figure 108: The inverse function for a Normal Density Function



NORMINV	
Probability	<input type="text"/>
Mean	<input type="text"/>
Standard_dev	<input type="text"/>

## 7.2.C

**CONFIDENCE INTERVALS**

*Menu path to function:* INSERT / FUNCTION / STATISTICAL / NORMINV.

*Data requirements:* The data series should follow the assumed Density Function type (Normal).

---

**95% Confidence Interval**

The Confidence Interval contains all but 2.5% of the extreme values on each of the tails of the Density Function (Probability Density Function (PDF)) or is the value that corresponds to 0.025 and 0.975 on the Cumulative Density Function (CDF). The 95% Confidence Interval for a series that follows a Normal Density Function with mean =  $\mu$  and standard deviation =  $\sigma$  is defined by the results of the two inverse



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functions at these two probabilities:

- NORMINV (0.025, mean, standard deviation)
- NORMINV (0.975, mean, standard deviation) for the lower and upper limit

---

### 90% Confidence Interval

The 90% Confidence Interval for a series that follows a Normal Density Function with mean =  $\mu$  and standard deviation =  $\sigma$  is defined by the results of the two inverse functions at these two probabilities:

- NORMINV (0.05, mean, standard deviation)
- NORMINV (0.95, mean, standard deviation) for the lower and upper limit

Table 16: Normal Density Function— Formulae for 90%, 95%, and 99% Confidence limits.

Confidence level	Formula for lower bound	Formula for upper bound
90%	NORMINV (0.05, mean, standard deviation) <sup>9</sup>	NORMINV (0.95, mean, standard deviation)
95%	NORMINV (0.025, mean, standard deviation)	NORMINV (0.975, mean, standard deviation)

---

<sup>9</sup> Note that many books use the following symbols or phrases for the mean and standard deviation”

- $\mu$  or “mu” for mean
- $\sigma$  or “sigma standard deviation/error
- $\sigma^2$  or “sigma square variance

Confidence level	Formula for lower bound	Formula for upper bound
99%	NORMINV (0.005, mean, standard deviation)	NORMINV (0.995, mean, standard deviation)

7.3

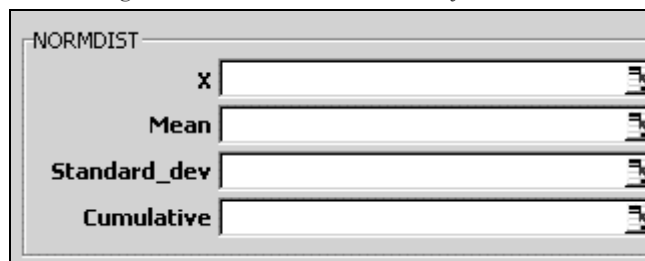
**STANDARD NORMAL OR Z-DENSITY FUNCTION**

The Cumulative Density Function (CDF) is the integral of the function on the right hand side in the above equation. The range of integration is negative infinity to the Z value being studied.

CDF:

NORMSDIST (z) → probability of values lying to the left of Z

Figure 109: The Normal Density Function



*Menu path to function:* INSERT / FUNCTION / STATISTICAL /NORMSDIST.

*Data requirements:* The data series ‘z’ should follow the assumed Density Function type (Standard Normal).

## Inverse function

This function calculates the inverse of the Standard Normal CDF. The inverse function for a Standard Normal Density Function requires only one parameter.

NORMSINV (probability below the X)  $\rightarrow$  X

Figure 110: NORMSINV

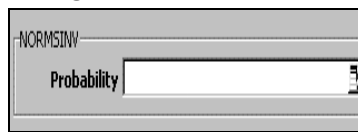
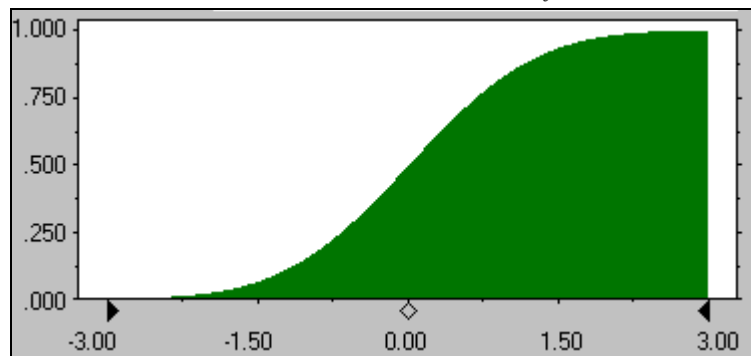


Figure 111: The cumulative Standard Normal Density Function (or the Probit)



*Menu path to function:* INSERT / FUNCTION / STATISTICAL / NORMSINV. *Data requirements:* The data series 'z' should follow the assumed Density Function type (Standard Normal).

## Confidence Intervals

Table 17: Standard Normal Density Function: Formulae for 90%, 95% and 99% Confidence limits.

Confidence level	Formula for lower bound	Formula for upper bound
------------------	-------------------------	-------------------------

Confidence level	Formula for lower bound	Formula for upper bound
90%	NORMSINV (0.05)	NORMSINV (0.95)
95%	NORMSINV (0.025)	NORMSINV (0.975)
99%	NORMSINV (0.005)	NORMSINV (0.995)

## 7.4

**T-DENSITY FUNCTION**CDF:

TDIST (x, degrees of freedom, tails) → probability of values lying to the left of X

In the box Tails, specify the number of tails to return.

- If tails = 1, TDIST returns the one-tailed Density Function.
- If tails = 2, TDIST returns the two-tailed Density Function.

For example, TDIST (1.96, 60, 2) equals 0.054645, or 5.46 percent

Figure 112: T-Distribution

The image shows a screenshot of the TDIST function dialog box in Microsoft Excel. The dialog box has a title bar that says 'TDIST'. Below the title bar, there are three input fields: 'x', 'Deg\_freedom', and 'Tails'. Each field has a small vertical line on its right side, indicating it is a text input field. The 'x' field is the top one, 'Deg\_freedom' is the middle one, and 'Tails' is the bottom one.

*Menu path to function:* INSERT /FUNCTION /STATISTICAL /TDIST.

*Data Requirements:* The data series should follow the T Density Function.

## Inverse function

This function calculates the t-value of the Student's t-Density Function as a function of the probability and the degrees of freedom.

TINV (probability below the X, degrees of freedom)  $\rightarrow$  X

Figure 113: The inverse function for a T-Density Function

A one-tailed t-value can be returned by replacing probability with  $2 \times$  probability. For a probability of 0.05 and degrees of freedom of 10, the two-tailed value is calculated with  $T(0.05, 10)$ , which returns 2.28139. The one-tailed value for the same probability and degrees of freedom can be calculated with  $T(2 \times 0.05, 10)$ , which returns 1.812462.

$TINV(0.054645, 60)$  equals 1.96

*Menu path to function:* INSERT /FUNCTION /STATISTICAL /TINV.

*Data requirements:* The data series should follow the assumed Density Function type (T).

## Confidence Intervals

Table 18: T Density Function— Formulae for 90%, 95%, and 99% Confidence limits (2 tails).

Confidence level	Formula for lower bound	Formula for upper bound
90%	$TINV(0.05, \text{degrees of freedom})$	$TINV(0.95, \text{degrees of freedom})$

Confidence level	Formula for lower bound	Formula for upper bound
95%	TINV (0.025, degrees of freedom)	TINV (0.975, degrees of freedom)
99%	TINV (0.005, degrees of freedom)	TINV (0.995, degrees of freedom)

7.4.A

**ONE-TAILED CONFIDENCE INTERVALS****95% Confidence Interval**

A 95 % Confidence Interval contains all but 5% of the extreme values on one-tail of the Density Function (Probability Density Function (PDF)) or is the value that corresponds to 0.05 or 0.95 on the Cumulative Density Function (CDF) (the former for the left tail of 5% and the latter for a right tail of 5%).

The 95% Confidence Interval for a T-distributed series is defined by the results of the two inverse functions at this probability:

Left tail: Negative infinity to TINV (0.05, degrees of freedom).

Right tail: TINV(0.95, degrees of freedom) to positive infinity.

Note:

$TINV(0.05, \text{degrees of freedom}) = -TINV(0.95, \text{degrees of freedom})$

**90% Confidence Interval**

A 90 % Confidence Interval contains all but 10% of the extreme values on one-tail of the Density Function (Probability Density Function (PDF)) or

is the value that corresponds to 0.1 or 0.9 on the Cumulative Density Function (CDF) (the former for the left tail of 10% and the latter for a right tail of 10%).

The 90% Confidence Interval for a T-distributed series is defined by the results of the two inverse functions at this probability:

- Left tail: Negative infinity to  $TINV(0.1, \text{degrees of freedom})$ .
- Right tail:  $TINV(0.9, \text{degrees of freedom})$  to positive infinity.

Note:

$$TINV(0.1, \text{degrees of freedom}) = -TINV(0.9, \text{degrees of freedom})$$

Table 19: T Density Function— Formulae for 90%, 95%, and 99% Confidence limits (right tail only).

Confidence level	Formula for lower left-tail Confidence upper limit (the lower limit equals negative infinity)
90%	$TINV(0.9, \text{degrees of freedom})$
95%	$TINV(0.95, \text{degrees of freedom})$
99%	$TINV(0.99, \text{degrees of freedom})$

Table 20: T Density Function— Formulae for 90%, 95%, and 99% Confidence limits (left tail only)

Confidence level	Formula for right-tail Confidence lower limit (the upper limit equals positive infinity)
90%	$-TINV(0.1, \text{degrees of freedom})$
95%	$-TINV(0.05, \text{degrees of freedom})$
99%	$-TINV(0.01, \text{degrees of freedom})$

7.5

**F-DENSITY FUNCTION**

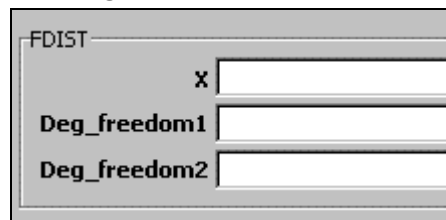
The F test is used for testing model significance and other joint hypothesis in ANOVA, Regression Analysis, etc.

**CDF:**

FDIST (x, numerator degrees of freedom, denominator degrees of freedom)

*Menu path to function:* INSERT / FUNCTION / STATISTICAL / FDIST.

Figure 114: F-Distribution



FDIST	
x	<input type="text"/>
Deg_freedom1	<input type="text"/>
Deg_freedom2	<input type="text"/>

*Data requirements:* The data series should follow the assumed Density Function type (F).

**Inverse function**

FINV (probability below the X, numerator degrees of freedom, denominator degrees of freedom)  $\rightarrow$  X

*Menu path to function:* INSERT / FUNCTION / STATISTICAL / FINV.

*Data requirements:* The data series should follow the F Density Function.



Figure 115: The inverse function for an F-Density Function

## One-tailed Confidence Intervals

Table 21: F Density Function— Formulae for 90%, 95%, and 99% Confidence Intervals (right tail only).

Confidence level	Formula for upper One-tail Confidence lower limit (the upper limit equals positive infinity)
90%	FINV (0.9, numerator degrees of freedom, denominator degrees of freedom)
95%	FINV (0.95, numerator degrees of freedom, denominator degrees of freedom)
99%	FINV (0.99, numerator degrees of freedom, denominator degrees of freedom)

7.6

## CHI-SQUARE DENSITY FUNCTION

The Chi-square test is used for testing model significance and other joint hypothesis in Maximum Likelihood estimation, Logit, Probit, etc.

The one-tailed probability of the Chi-Square Density Function: CDF:

CHIDIST (x, degrees of freedom) → probability of values lying to the left of X

Figure 116: CHI-Square Density Function

*Menu path to function:* INSERT /FUNCTION /STATISTICAL /CHIDIST.

*Data requirements:* The data series should follow the assumed Density Function type (Chi-Square).

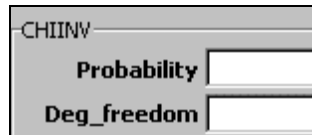
### Inverse function

CHIINV (probability, degrees of freedom)  $\rightarrow X$

*Menu path to function:* INSERT /FUNCTION /STATISTICAL /CHIINV.

*Data requirements:* The data series should follow the Chi-Square Density Function.

Figure 117: CHIINV



### One-tailed Confidence Intervals

Table 22: Chi-Square Density Function: Formulae for 90%, 95%, and 99% Confidence limits (right tail only). Samples will be available at <http://www.vjbooks.net/excel/samples.htm>.

Confidence level	Formula for upper One-tail Confidence lower limit (the upper limit equals positive infinity)
90%	CHIINV (0.9, degrees of freedom)
95%	CHIINV (0.95, degrees of freedom)
99%	CHIINV (0.99, degrees of freedom)

7.7

**OTHER CONTINUOUS DENSITY FUNCTIONS: BETA, GAMMA, EXPONENTIAL, POISSON, WEIBULL & FISHER**

7.7.A

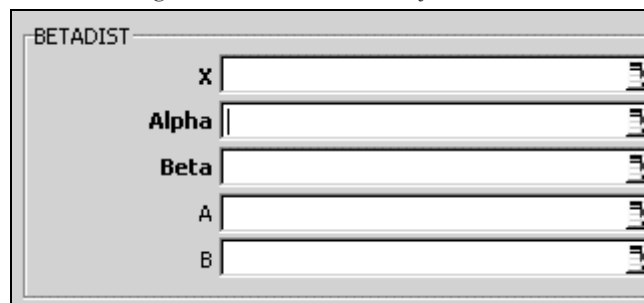
**BETA DENSITY FUNCTION**CDF:

BETADIST (x, alpha, beta, lower bound A, upper bound B) → probability of values lying to the left of X

*Menu path to function:* INSERT / FUNCTION / STATISTICAL / BETADIST.

*Data requirements:* The data series should follow the Beta Density Function.

Figure 118: BETA Density Function



BETADIST	
X	<input type="text"/>
Alpha	<input type="text"/>
Beta	<input type="text"/>
A	<input type="text"/>
B	<input type="text"/>

---

Figure 119: Note how the Density Function Probability Density Function (PDF) is skewed to one side and has a less sharp “hill” at top — compared to a Normal Probability Density Function (PDF)

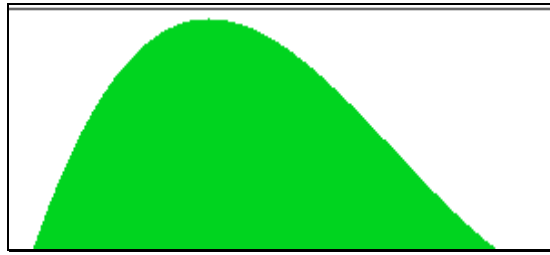
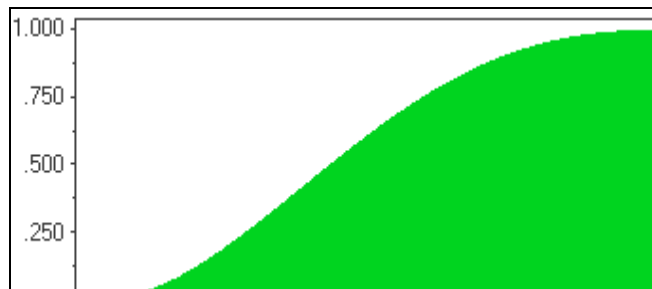


Figure 120: The Cumulative Density Function (CDF) shows (on the Y -Axis) the proportion of values that lie below a certain X value of the series



---

## Inverse Function

BETA.INV (probability, alpha, beta, lower bound A, upper bound B) → X

*Menu path to function:* INSERT / FUNCTION / STATISTICAL /  
BETA.INV.

*Data requirements:* The data series should follow the assumed Density Function type (Beta).

Figure 121: The inverse function for a BETA Density Function

BETAINV	
<b>Probability</b>	<input type="text"/>
<b>Alpha</b>	<input type="text"/>
<b>Beta</b>	<input type="text"/>
A	<input type="text"/>
B	<input type="text"/>

## Confidence Intervals

Table 23: BETA Density Function— Formulae for 90%, 95%, and 99% Confidence limits.

Confidence level	Formula for lower bound	Formula for upper bound
90%	BETAINV (0.05, alpha, beta, A, B)	BETAINV (0.95, alpha, beta, A, B)
95%	BETAINV (0.025, alpha, beta, A, B)	BETAINV (0.975, alpha, beta, A, B)
99%	BETAINV (0.005, alpha, beta, A, B)	BETAINV (0.995, alpha, beta, A, B)

### 7.7.B GAMMA DENSITY FUNCTION

The Gamma Density Function is commonly used in queuing analysis.

#### CDF:

GAMMADIST (x, Alpha, Beta, true) → probability of values lying to the left of X)

#### PDF:


GAMMADIST (x, Alpha, Beta, false) → probability of values taking the value X)

*Menu path to function:* INSERT /FUNCTION /STATISTICAL

---

/GAMMADIST.

Figure 122: GAMMA Density Function



The image shows a dialog box for the GAMMADIST function. It has a title bar labeled 'GAMMADIST'. Below the title bar, there are four input fields with labels to their left: 'x', 'Alpha', 'Beta', and 'Cumulative'. Each field is a simple rectangular box with a vertical line on the left side, indicating it is a text input field.

*Data requirements:* The data series should follow the assumed Density Function type (Gamma).

---

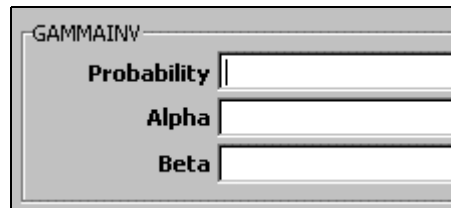
## Inverse Function

GAMMAINV (probability below the X, alpha, beta)  $\rightarrow$  X

*Menu path to function:* INSERT /FUNCTION /STATISTICAL /GAMMAINV.

*Data requirements:* The data series should follow the assumed Density Function type (Gamma).

Figure 123: The inverse function for a GAMMA Density Function



The image shows a dialog box for the GAMMAINV function. It has a title bar labeled 'GAMMAINV'. Below the title bar, there are three input fields with labels to their left: 'Probability', 'Alpha', and 'Beta'. Each field is a simple rectangular box with a vertical line on the left side, indicating it is a text input field.

---

## Confidence Intervals

Table 24: Gamma Density Function: Formulae for 90%, 95% and 99% Confidence limits.  
Samples will be available at <http://www.vjbooks.net/excel/samples.htm>.

Confidence level	Formula for lower bound	Formula for upper bound
90%	GAMMAINV (0.05, alpha, beta)	GAMMAINV (0.95, alpha, beta)
95%	GAMMAINV (0.025, alpha, beta)	GAMMAINV (0.975, alpha, beta)
99	GAMMAINV 0005, alpha, beta	GAMMAINV 0995, alpha, beta

If an inverse function does not converge after 100 iterations, the function returns the #N/A error value.

### 7.7.C

## EXPONENTIAL DENSITY FUNCTION

### PDF:

EXPONDIST (x, lambda, False) → probability of values taking the value X

### CDF:

EXPONDIST (x, lambda, True) → probability of values lying to the left of X

*Menu path to function:* INSERT /FUNCTION /STATISTICAL /EXPONDIST.

*Data requirements:* The data series should follow the Exponential Density Function.

Figure 124: Dialog for the Exponential Distribution

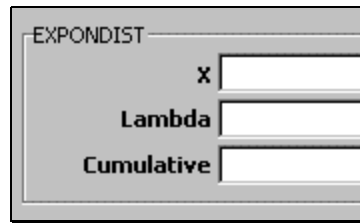


Figure 125: Exponential Probability Density Function (PDF)

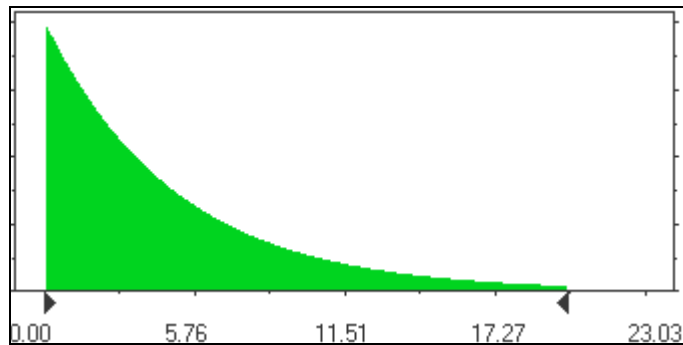
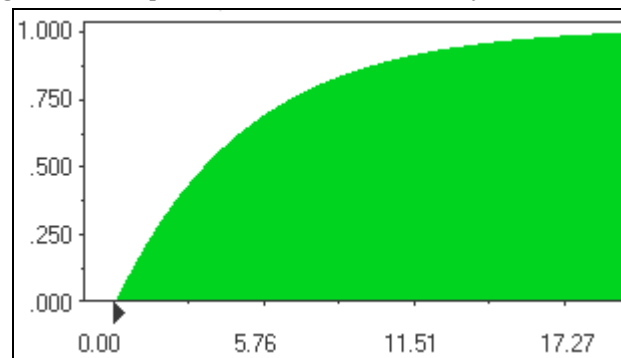


Figure 126: Exponential Cumulative Density Function (CDF)



EXPONDIST (0.2, 10, TRUE) equals 0.864665 while EXPONDIST (0.2, 10, FALSE) equals 1.353353

Further detail is beyond the scope of this book.



7.7.D **FISHER DENSITY FUNCTION**

This topic is beyond the scope of this book.

7.7.E **POISSON DENSITY FUNCTION**

This Density Function is used for predicting the number of events 'X' occurring over a specific time.

PDF:

POISSON (x, expected value, false) → probability of values taking the value X

CDF:

POISSON (x, expected value, true) → probability of values lying to the left of X

Further detail is beyond the scope of this book.

7.7.F **WEIBULL DENSITY FUNCTION**

PDF:

WEIBULL (x, a, b, false) → probability of values taking the value X

CDF:

WEIBULL (x, a, b, true) → probability of values lying to the left of X

Further detail is beyond the scope of this book.

7.7.G

## **DISCRETE PROBABILITIES— BINOMIAL, HYPERGEOMETRIC & NEGATIVE BINOMIAL**

This topic is beyond the scope and aim of this book.

---

### **Binomial Density Function**

This function is used to ascertain the probability of obtaining a “head” in a coin toss.  $X$  can take only two discrete values. Further detail is beyond the scope of this book.

---

### **Hypergeometric Density Function**

The Density Function captures event probabilities in problems of sampling without replacement. The sample is taken from a discrete finite population like a deck of cards. Further detail is beyond the scope of this book.

---

### **Negative Binomial**

This function measures the probability of “number of coin tosses before first or  $K^{\text{th}}$  heads (in a coin toss).”

7.8

**LIST OF DENSITY FUNCTION**

Table 25: PDF and CDF functions

Function	Is there a function that does the converse of this mapping and, if so, the name of the function?	Is there an option to request the cumulative probability?	Information required by all functions	Other information requirements			
			Value (s) for which the probability is being sought	Mean	Std Dev	Degrees of freedom	Other
TDIST	TINV		✓			✓	
LOGNORMDIST	LOGINV	✓	✓	✓	✓		
FDIST	FINV		✓			✓	2 <sup>nd</sup> degree of freedom
BETADIST	BETAINV		✓	alpha, beta, upper and lower bound			
CHIDIST	CHIINV		✓			✓	
NORMDIST	NORMINV	✓	✓	✓	✓		
NORMSDIST	NORMSINV	✓	✓				
WEIBULL			✓				alpha, beta
NEGBINOMDIST	—		# of failures	(Probability)			# of successes
BINOMDIST	—	✓	# of successes	(Probability)			
EXPONDIST	—	✓	✓				Lambda
GAMMADIST	GAMMAINV	✓	✓				alpha, beta
HYPGEOMDIST	—		# of successes in sample	Sample & population size, # of successes in population			
POISSON	—	✓	✓	✓			

## 7.9

**SOME INVERSE FUNCTION**

Table 26: Inverse Functions

Function	Inverse mapping ("probability to value") of which cumulative probability function?	Information required by all inverse functions	Other information requirements			
		Probability for which the corresponding value is sought	Mean	Std Dev	Degrees of freedom	Other
TINV	TDIST	✓			✓	
LOGINV	LOGNORMDIST	✓	✓	✓		
FINV	FDIST	✓			✓	2 <sup>nd</sup> degree of freedom
BETAINV	BETADIST	✓		alpha, beta, Upper and lower bound		
CHIINV	CHIDIST	✓			✓	
NORMINV	NORMDIST	✓	✓	✓		
NORMSINV	NORMSDIST	✓				





## CHAPTER 8

# OTHER MATHEMATICS & STATISTICS FUNCTIONS

This chapter briefly displays some other functions available in Excel. The topics in this chapter are:

- COUNTING AND SUMMING
- COUNT, COUNTA
- COUNTBLANK
- COMPARING COUNT, COUNTA AND COUNTBLANK
- SUM
- PRODUCT
- SUMPRODUCT
- THE “IF “COUNTING AND SUMMING FUNCTIONS
- SUMIF
- COUNTIF
- TRANSFORMATIONS (LIKE LOG, EXPONENTIAL, ABSOLUTE, ETC)
- STANDARDIZING A SERIES THAT FOLLOWS A NORMAL DENSITY FUNCTION
- DEVIATIONS FROM THE MEAN
- CROSS SERIES RELATIONS
- COVARIANCE AND CORRELATION FUNCTIONS
- SUM OF THE SUM OF THE SQUARES OF TWO VARIABLES

- 
- SUM OF THE SQUARES OF DIFFERENCES ACROSS TWO VARIABLES
  - SUM OF THE DIFFERENCE OF THE SQUARES OF TWO VARIABLES

## 8.1

**COUNTING AND SUMMING**

---

**COUNT function**

This function counts the number of valid cells in a range. Cells are valid only if their value is numeric or a date.

*Menu path to function:* INSERT /  FUNCTION /  STATISTICAL /  COUNT.

*Data requirements:* Numbers and dates are included in the count. Not counted cells include those that contain error values, text, blank cells, and logical values (like TRUE and FALSE). The X values can be input as references to one or more ranges that may be non-adjacent.

The second range can be referenced in the first text-box “Value1” after placing a comma after the first range, or it could be referenced in the second text-box “Value2.”

If you use the second text-box, then a third text-box “Value3” will automatically open. (As you fill the last visible box, another box opens until the maximum number of boxes — 30 — is reached.)



Table 27: Sample data for the “Count” functions.  
The example is in the sample file “Count.xls.”

A	B	C	D
	Y	Date	Respondent is employed
.51	24.34	24— Sep— 2000	TRUE
20.07	24.34	25— Sep— 2000	FALSE
VALUE!	24.34	26— Sep— 2000	#VALUE!
15.28	24.34	27— Sep— 2000	FALSE
DIV/0!	#VALUE!	28— Sep— 2000	TRUE
11.63	24.34	29— Sep— 2000	#N/A!
.86		30— Sep— 2000	TRUE
REF!	22.00	1— Oct— 2000	FALSE
.74	22.00		TRUE
NAME?	22.00	3— Oct— 2000	
.13	22.00	4— Oct— 2000	TRUE
N/A!	21.58	5— Oct— 2000	TRUE

Figure 127: COUNT

	A	B	C	D	E	F	G	H
1	X	Y	date	Respondent is employed		A	B	C
2	1.51	24.34	24-Sep-00	TRUE	COUNT	=COUNT(A2:A13)		
3	20.07	24.34	25-Sep-00	FALSE	COUNTA			
4	#VALUE!	24.34	26-Sep-00	#VALUE!	COUNTBLANK			
5	15.28							
6	#DIV/0!	#V						
7	11.63							
8	8.86							
9	#REF!							
10	6.74							
11	#NAME?							
12	5.13	22	4-Oct-00	TRUE				
13	#N/A!	21.58	5-Oct-00	TRUE				

COUNT

**Value1** A2:A13 = {1.51;20.07;#VALUE

**Value2** = number

= 7

Counts the number of cells that contain numbers and numbers within the list of arguments.

**Value1:** value1,value2,... are 1 to 30 arguments that can contain or refer to a variety of different types of data, but only numbers are counted.

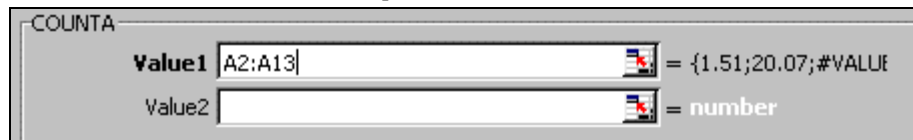
Formula result = 7

OK Cancel

## COUNTA function also counts cells with logical or text values

This function counts the number of valid cells in a range. Valid values include cells with numeric, date, text, logical, or error value. COUNTA only excludes empty cells, but text and logical values are only counted if you type them directly into the list of arguments are counted. If an argument is a data array or range reference, only numbers in that data array or range reference.

Figure 128: The function COUNTA is a variant of the COUNT function. The example is in the sample file “Count.xls.”



*Menu path to function:* INSERT / FUNCTION / STATISTICAL / COUNTA.

*Data requirements:* Unlike the COUNT function, COUNTA will include the label row in the count. (So, if you have one label in the referenced range, you may want to use “= COUNTA (A:A) — 1”.) The X values can be input as references to one or more ranges that may be non-adjacent. The second range can be referenced in the first text-box “Value1” after placing a comma after the first range, or it could be referenced in the second text-box “Value2.” If you use the second text-box, then a third text-box “Value3” will automatically open. (As you fill the last visible box, another box opens until the maximum number of boxes — 30 — is reached.) The function does not count invalid cell values when counting the number of X values.

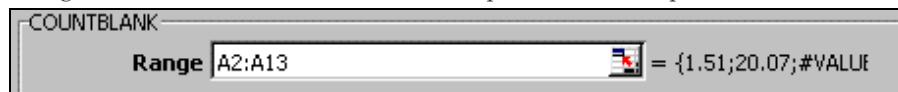
---

## COUNTBLANK function counts the number of empty cells in the range reference

This function counts the number of blank cells in a range.

*Menu path to function:* INSERT /FUNCTION  
/INFORMATION/COUNTBLANK.

Figure 129: COUNTBLANK. The example is in the sample file “Count.xls.”




---

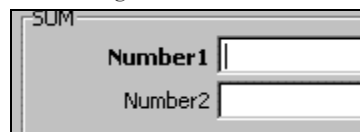
## SUM function

This function sums the values in the data array.

$$\text{SUM} = X_1 + X_2 + \dots + X_n$$

*Menu path to function:* INSERT / FUNCTION / MATH / SUM.

Figure 130: SUM



*Data requirements:* This function does not include blank cells or cells with values that are of the following formats: text, and logical values (that is, TRUE and FALSE.)

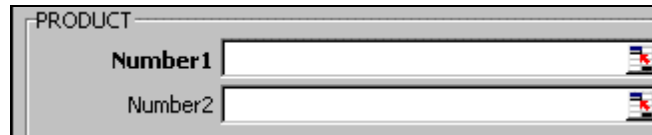
---

## PRODUCT function

This function multiplies all the values referenced.

$$\text{PRODUCT} = X_1 * X_2 * \dots * X_n$$

Figure 131: PRODUCT (multiplying all the values in a range)



Menu path to function: INSERT / FUNCTION / MATH / PRODUCT.

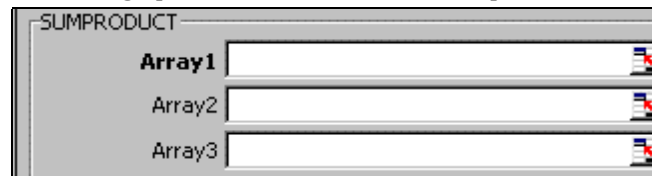
---

## SUMPRODUCT function

This function multiplies corresponding components in two or more data arrays/ranges, and then sums the results of these multiplications. The data arrays/ranges must have the same number of data points.

*Menu path to function:* INSERT /FUNCTION /MATH /SUMPRODUCT

Figure 132: SUMPRODUCT (multiplying individual data points across data series and then adding up the results of all these multiplications).



Data Array1, data Array2, data Array3 ... are 2 to 30 data arrays/ranges whose components you desire to multiply and then add. The minimum number of arrays is two. The data arrays must have the same number of data points. Non-numeric cell values are assigned the value of zero.

---

The X values can be input as references to two or more ranges that may be non-adjacent. The second range should be referenced in the second text-box “Array2.” If you use the third text-box, then a fourth text-box “Array4” will automatically open. (As you fill the last visible box, another box opens until the maximum number of boxes — 30 — is reached.)

### Example

The following formula multiplies all the components of the two data arrays on the preceding worksheet and then adds the products— that is,  $3*2 + 4*7 + 8*6 + 6*7 + 1*5 + 9*3$ .

### Note:

Samples will be available at <http://www.vjbooks.net/excel/samples.htm>.

---

8.2

## THE “IF” COUNTING AND SUMMING FUNCTIONS: STATISTICAL FUNCTIONS WITH LOGICAL CONDITIONS

I display two “if-then” two-step functions in this section. The functions first evaluate a criterion. If a cell in the referenced range satisfies the criteria then the second part of the function includes this cell.

---

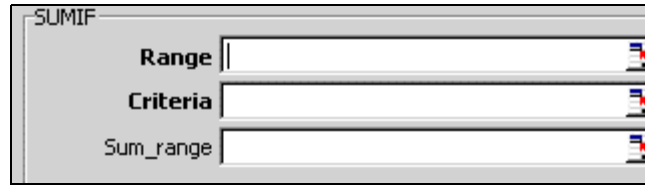
### SUMIF function

This function adds the values in a range if the cell with the value satisfies a user-defined criterion.

- In the box *Range*, enter a reference to the range of cells you want

evaluated.

Figure 133: SUMIF (summing only the cells whose value satisfies one “if” condition)



- In the box *Criteria*, enter the condition (a number, expression, or text) that defines which cells values will be summed. For example, *Criteria* can be expressed as 32, “32,” “>32”.
- In the box *Sum\_range*, you may reference the actual cells to sum. The cells in sum range are summed only if their corresponding cells in the entire *Range* match the criteria. If sum range is omitted, all the “criterion-satisfying” cells in the *Range* are summed.

*Menu path to function:* INSERT / □FUNCTION / □MATH / □SUMIF. The *Criteria* should be relevant to the type of data/text in the queried range.

---

## COUNTIF function

This function counts the number of cells in a range that satisfy a user-defined criterion.

The dialog for “COUNTIF” requires two inputs from the user. The “Range” is similar to the functions shown previously. The “Criteria” is a logical condition set by you.

Figure 134: COUNTIF (counting only the cells whose value satisfies one “if” condition)

 A screenshot of the COUNTIF dialog box. The title bar reads "COUNTIF". There are two input fields: "Range" and "Criteria". Both fields are currently empty. To the right of each field is a small icon with a red 'X' and a blue checkmark, likely for validation or help.

- In the box *Range*, enter a reference to the range of cells you seek to evaluate.
- In the box *Criteria*, enter the condition (a number, expression, or text) that defines which cells will be counted. For example, *Criteria* can be expressed as 32, “32,” “>32,” “tea.”

*Menu path to function:* INSERT /FUNCTION /STATISTICAL /COUNTIF.

*Data requirements:* The range can take any values. The Criteria should be relevant to the type of data/text in the queried range.

### Example

Choose the range “D:D” and the condition “>1,000,000”. The function is “Count the number of cases in the range D:D, but only if the value of the cell is greater than 1 million.”

For a pictorial reproduction of this, see the next figure.

Figure 135: Entering the data input and logical criterion

 A screenshot of the COUNTIF dialog box with data entered. The title bar reads "COUNTIF". The "Range" field contains "D:D" and the "Criteria" field contains ">1,000,000". To the right of each field is a small icon with a red 'X' and a blue checkmark, followed by an equals sign and the text "= D:D" for the range and "= ">1,000,000" for the criteria.

Execute the dialog by clicking on the button OK. The formula is written

onto the cell. The next figure illustrates this. Depress the ENTER key.

Figure 136: The function as written into the cell

=COUNTIF(D:D,">1,000,000")

8.3

**TRANSFORMATIONS (LOG, EXPONENTIAL, ABSOLUTE, SUM, ETC)**

Table 28: Common transformation functions

<i>Function</i>	<i>Description</i>	<i>Location within INSERT /FUNCTION</i>	<i>Data Requirements</i>
Sign	This function outputs the sign of a number. Returns 1 if the number is positive, zero (0) if the number is 0, and -1 if the number is negative. Useful for red-flagging data, or using in functions like IF, COUNTIF, SUMIF and CHOOSE.	MATH /SIGN	Any real value.
Absolute number	ABS =   X	MATH /ABS	One real number.
Square root	The square root of a number.	MATH/SQRT	One positive real number.



<i>Function</i>	<i>Description</i>	<i>Location within INSERT /FUNCTION</i>	<i>Data Requirements</i>
	$Y = X^{1/2}$		
Log natural	<p>LN (X)</p> <p>This function calculates the natural logarithm of a number. Natural logarithms are based on the constant <math>e</math> (2.718).</p> <p>LN (85) = 4.454347.</p> <p>This mean: "If you raise the base <math>e</math> to the power of 4.45 you will get 85. <math>\rightarrow</math> LN (85) = 4.45.</p> <p>Conversely,  <math>\exp(4.45) = e^{(4.45)} = 2.718^{(4.45)} = 85</math>.</p>	MATH /LN	One positive real number.
Exponential	This function calculates the exponential to a number.	MATH /EXP	One positive real number.
Log to the base 10	<p>LOG10 (X)</p> <p>This function calculates the base 10 logarithm of a number.</p> <p>LOG10 (85) = 1.934 because the base of 10 needs to be raised 1.934 times to get 85:  <math>10^{1.934} = 85</math></p> <p>LOG10 (10) = 1 because <math>10^1 = 10</math></p> <p>LOG10 (1000) = 3 because <math>10^3 = 1000</math></p>	MATH /LOG10	One positive real number.

<i>Function</i>	<i>Description</i>	<i>Location within INSERT /FUNCTION</i>	<i>Data Requirements</i>
Log to a user defined base	<p>This function calculates the logarithm of a number to the base you specify. The default base is 10. For natural log use base e = 2.718.</p> <p>LOG (X, base)</p> <p>LOG (100) = 2 → base 10. (Since <math>10^2 = 100</math>).</p> <p>LOG (27, 3) = 3 → base 3. (Since <math>3^3 = 27</math>).</p> <p>LOG (86, 2.7182818) = 4.45 → same as natural log. Because— (exp (4.45) = 85).</p>	MATH/LOG.	<p>A positive real number <math>X</math> and the (optional) <i>base</i> of the logarithm.</p> <p>If base is omitted, it is assumed = 10.</p>

### Standardizing a series that follows a Normal Density Function

Converts a value in a series  $X$  to its equivalent standard normal transformation.

STANDARDIZE (x, AVERAGE (X), STDEV (X)) where  $X$  is all the numbers in the  $X$  data series.

*Menu path to function:*

INSERT/FUNCTION/STATISTICAL/STANDARDIZE.

*Data requirement:* The function requires three input numbers:  $x$ , mean of the  $X$  series, and the standard deviation of the  $X$  series. The mean and standard deviation can be written as a “function within a function.”

## 8.4

**DEVIATIONS FROM THE MEAN**

The formulas in this and the next section provide estimates of functions used in formulas for parameters obtained in advanced analysis like ANOVA, Correlation, Regression, etc.

**DEVSQ**

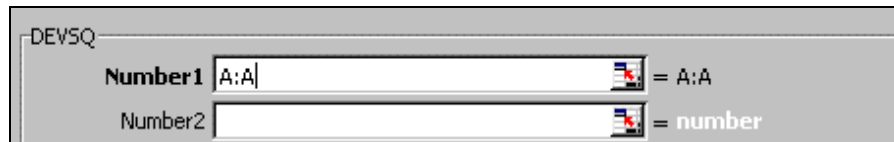
This function calculates the sum of squares of deviations of data points from their sample mean

$$\Sigma ((x - \text{mean}(x))^2)$$

*Menu path to function:* MATH/DEVSQ

*Data Requirements:* A range(s) of real numbers, inclusive of zero.

Figure 137: Summation of the squares of the “differences of individual points from the mean of the series”

**AVEDEV**

This function calculates the average of the absolute deviations of data points from their mean. AVEDEV is a measure of the variability in a data set.

---

$$\frac{1}{n} \sum |x - \bar{x}|$$

*Menu path to function:* STATISTICAL/AVEDEV

*Menu path to function:* A range(s) of real numbers, inclusive of zero.

---

8.5

## CROSS SERIES RELATIONS

8.5.A

### COVARIANCE AND CORRELATION FUNCTIONS

The functions are CORREL, COVAR, PEARSON, & RSQ. I recommend using the Analysis ToolPak Add-In — refer to 10.3.

8.5.B

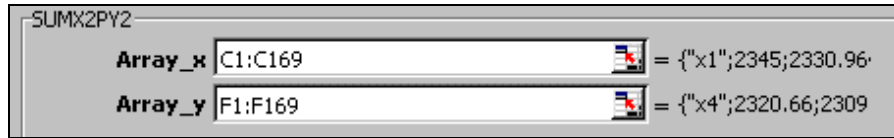
### SUM OF SQUARES

SUMX2PY2 function evaluates the “Sum of the sum of the squares of each case in two variables”

This function estimates the summation of the squares of individual points in two series.

$$\Sigma (x^2 + y^2)$$

Figure 138: Summation of the squares of individual points in two series. Samples will be available at <http://www.vjbooks.net/excel/samples.htm>.



*Menu path to function:* INSERT/FUNCTION/MATH/SUMX2PY2.

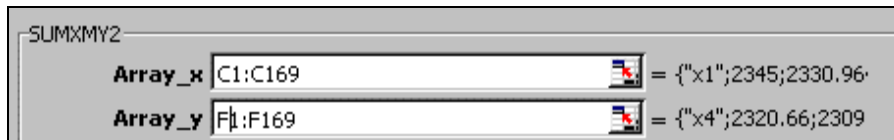
*Data requirements:* This function needs two data series.

### SUMXMY2 function

This function estimates Sum of the squares of differences of each case in two across two variables.

$$\Sigma ((x - y)^2)$$

Figure 139: Summation of the squares of the “differences in individual points in two series.” Samples will be available at <http://www.vjbooks.net/excel/samples.htm>.



*Menu path to function:* INSERT/FUNCTION/MATH/SUMXMY2. *Data requirements:* This function needs two data series.

### SUMX2MY2 function

This function estimates the Sum of the difference of the squares of each case in two variables.

$$\Sigma (x^2 - y^2)$$

*Menu path to function:* INSERT/FUNCTION/MATH/SUMX2MY2.

*Data requirements:* This function needs two data series.



## **CHAPTER 9**

### ADD-INS: ENHANCING EXCEL

This chapter discusses the following topics:

- WHAT CAN AN ADD-IN DO?
- WHY USE AN ADD-IN (AND NOT JUST EXCEL  
MACROS/PROGRAMS)?
- ADD-INS INSTALLED WITH EXCEL
- OTHER ADD-INS
- THE STATISTICS ADD-IN
- CHOOSING THE ADD-INS

---

#### 9.1

#### **ADD-INS: INTRODUCTION**

An “Add-In” is a software application that adds new functionality to Excel. The Add-In typically seamlessly fits into the Excel interface, providing accessibility to its functionality through

- new menus
- new options in existing menus
- new functions



— new toolbars and specific toolbar icons

### 9.1.A                    **WHAT CAN AN ADD-IN DO?**

Almost anything an imaginative software developer could create. Usually, an Add-In provides functionality that is useful for a particular type of analysis/industry — statistics, finance, real estate, etc.

### 9.1.B                    **WHY USE AN ADD-IN?**

The Add-In could have its base code written in software languages like C, C++, FORTRAN, Pascal, etc. This is important because some algorithms and operations (like simulations) operate best when written in a specific language. Therefore, the developer uses the best language/tool to create the functionality and then packages this inside an Add-In.

---

## 9.2                    **ADD-INS INSTALLED WITH EXCEL**

Some Add-Ins are available in the Microsoft Office CD-ROM and are installed (but not activated<sup>10</sup>) along with Excel. I show the use of three Add-ins.

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<sup>10</sup> Figure 540 and Figure 542 show how to activate the Add-ins

## 9.3

**OTHER ADD-INS**

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Many commercially sold Add-Ins can be almost like separate software just needing Excel as the “host.” Two examples:

- Crystal Ball™ risk analysis software
  
- *UNISTAT*™ software for conducting advanced statistics and econometrics from inside Excel

Hundreds of software companies construct Add-Ins. The greatest contribution of this book, if I succeed in doing so, would be the opening of this massive potential functionality to Excel users.

## 9.4

**THE STATISTICS ADD-IN**

---

The Analysis ToolPak Add-In that ships with Excel can conduct several procedures including descriptives, regression, ANOVA, F-test, correlation, T-tests, moving average, and histogram. Let us learn how to use this “Add-In.”

## 9.4.A

**CHOOSING THE ADD-INS**

Choose the menu option **TOOLS/ADD-INS**. You will see several Add-Ins as shown in Figure 140. (You may not see all the Add-Ins shown in the next two figures.)

Figure 140: Selecting an Add-In

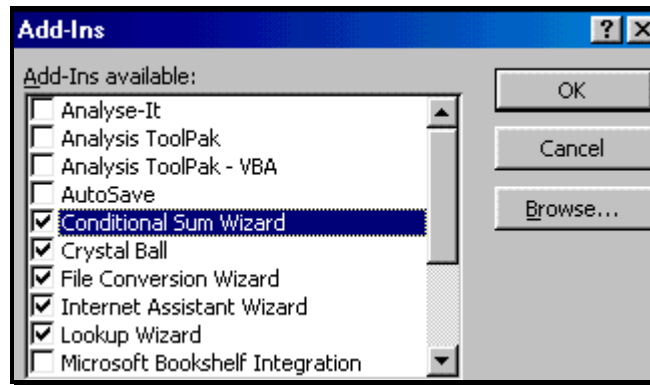
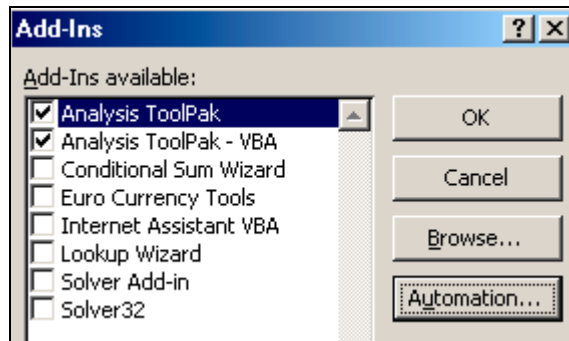


Figure 141: In Excel XP, the Add-Ins dialog provides access to “Automation.” This topic is beyond the scope of this book.



You need the “Analysis ToolPak Add-Ins.” Select — by clicking on it — the box to the left of these Add-Ins (shown in Figure 142). Execute the dialog by clicking on the button OK and wait for some time while the Add-Ins are “loaded” or “registered” with Excel. An Add-In has to be loaded/registered before it is available for use. The Add-In remains loaded across sessions. It is only “unloaded” when you select the option

---

TOOLS/ADD-INS and deselect the Add-In<sup>11</sup>.

Figure 142: The Add-In pair for data analysis



You have activated the “Analysis ToolPak.” At the bottom of the menu TOOLS, you will see the option “DATA ANALYSIS” at the bottom— this option was not there before you accessed the Add-In. (This is illustrated in Figure 143.)

The statistical procedures are accessed through this new option.

Note:

Usually Add-Ins expose their functionality by creating new menu options or even new menus. The menu option “Data analysis” provides the statistics functionality available in “Analysis ToolPak” and “Analysis ToolPak VB.” The menu options “Optquest” down till “CB Bootstrap” are linked to the Add-in “Crystal Ball” (not shipped in the Office CD-ROM).

---

<sup>11</sup> If too many Add-Ins are loaded, Excel may work too slowly, or even freeze. If you find this problem occurring, then just load the Add-in when you are going to use it and unload it before quitting Excel.

Figure 143: The “Data Analysis” menu option







## **CHAPTER 10**

### STATISTICS TOOLS

This chapter discusses the following topics:

- DESCRIPTIVE STATISTICS
- RANK AND PERCENTILE
- BIVARIATE RELATIONS— CORRELATION, COVARIANCE

A proper analysis of data must begin with an analysis of the statistical attributes of each series in isolation — univariate analysis. From such an analysis, you can learn:

- How the values of a series are distributed — normal, binomial, etc.
- The central tendency of the values of a series (mean, median, and mode)
- Dispersion of the values (standard deviation, variance, range, and quartiles)
- Presence of outliers (extreme values)



The answer to these questions illuminates and motivates further, more complex, analysis. Moreover, failure to conduct univariate analysis may restrict the usefulness of further procedures (like correlation and regression). Reason: even if improper/incomplete univariate analysis may not directly hinder the conducting of more complex procedures, the interpretation of output from the latter will become difficult (because you will not have an adequate understanding of how each series behaves).

Note: I do not go into the details of each statistics procedure. For such details, refer to your statistics textbook or to “SPSS for Beginners” (available at <http://www.vjbooks.net> and [amazon.com](http://amazon.com)).

This chapter requires the Analysis ToolPak Add-Ins; chapter 9 shows how to learn how to launch the Add-Ins.

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**10.1****DESCRIPTIVE STATISTICS**

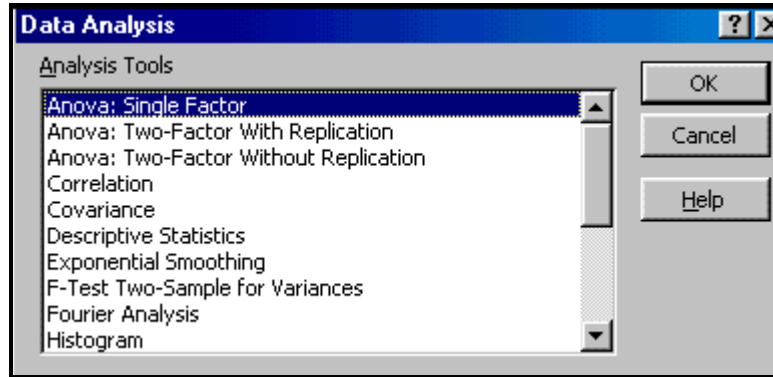
*I do not supply the sample data for most of the examples in chapters 36-40. My experience is that many readers glaze over the examples and do not go through the difficult step of drawing inferences from a result if the sample data results are the same as those in the examples in the book.*

Choose the menu option **TOOLS/DATA ANALYSIS**<sup>12</sup>. The dialog shown in Figure 144 opens.

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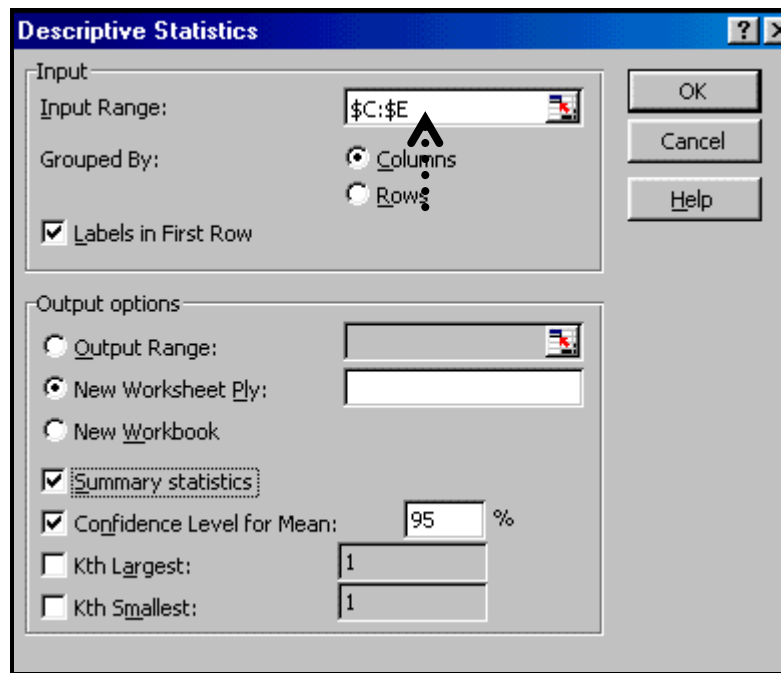
<sup>12</sup> If you do not see this option, then use **TOOLS / ADD-INS** to activate the Add-In for data analysis. Refer to section 41.4.

Figure 144: The options for the menu TOOLS/DATA ANALYSIS



Choose the statistical procedure “Descriptive Statistics.” The dialog for “Descriptive Statistics” opens. Figure 145 shows this dialog (user-input form).

Figure 145: Descriptive Statistics dialog



Input (or, “Source”) data

Choose the data series whose descriptives you desire. Click on the edge of the box next to “Input Range” (at the point where the dotted arrow points in Figure 145).

Options

Choose other options shown in Figure 145. Select the option “Labels in first row” because the names of the three series are in the first row of the range you selected (the labels are in cells C1, D1, and E1)— this way Excel picks up the names of the variables and uses these names in the output<sup>13</sup>. Execute the dialog by clicking on the button OK.

Output

Excel produces the descriptive statistics and places the results in a new worksheet. (This is illustrated in Figure 146.)

---

<sup>13</sup> Note that in the output of this procedure (shown in Figure 546) the first row has the labels for the three variables— 1995, 2000, and 2010.

Figure 146: Output of Descriptive Statistics procedure

A	B	C	D	E	F
1995		2000		2010	
Mean	5257914.9	Mean	9440351.4	Mean	7406944.7
Standard Err	2665017.3	Standard Err	5047964.7	Standard Err	3748949.2
Median	492000	Median	589000	Median	799000
Mode	47000	Mode	254000	Mode	51000
Standard Deviation	40853942	Standard Deviation	77383834	Standard Deviation	57470302
Sample Variance	1.669E+15	Sample Variance	5.988E+15	Sample Variance	3.303E+15
Kurtosis	218.59277	Kurtosis	179.18282	Kurtosis	219.84937
Skewness	14.560356	Skewness	13.001367	Skewness	14.619033
Range	617798000	Range	1.109E+09	Range	870291000
Minimum	7000	Minimum	12000	Minimum	25000
Maximum	617805000	Maximum	1.109E+09	Maximum	870316000
Sum	1.236E+09	Sum	2.218E+09	Sum	1.741E+09
Count	235	Count	235	Count	235
Confidence Level	5250489.2	Confidence Level	9945257.7	Confidence Level	7385999.6

This tool generates a report of univariate statistics for data in the input range, providing information about the central tendency and variability of your data

### Example 2: Adding additional parameters to the descriptives table

Go to the menu option TOOLS/DATA ANALYSIS. Select the option “Descriptive Statistics.” In addition to the statistics requested in the previous example, I request Excel to report on the fifth largest and fifth smallest values for each column/series.

Figure 147: The Descriptives Statistics dialog

### Output

The output for the procedure is reproduced in the next table. In one simple step, you have created a table that captures the basic statistical attributes of several data series and the fifth highest and lowest values of each data series.

Table 29: Output of the Descriptive Statistics tool including the Kth largest and smallest values. The names of the three variable are: s1, s2, and x1.

s1		s2		x1	
Mean	7.32	Mean	7.23	Mean	1173.00
Standard Error	0.44	Standard Error	0.49	Standard Error	52.67
Median	5.31	Median	4.81	Median	1173.00
Mode	1.34	Mode	23.00	Mode	#N/A
Standard Deviation	5.72	Standard Deviation	6.33	Standard Deviation	682.73
Sample	32.68	Sample	40.13	Sample	466119.22

s1		s2		x1	
Variance		Variance		Variance	
Kurtosis	-0.22	Kurtosis	0.04	Kurtosis	-1.20
Skewness	0.95	Skewness	1.06	Skewness	0.00
Range	19.66	Range	22.00	Range	2344.00
Minimum	1.34	Minimum	1	Minimum	1
Maximum	21	Maximum	23	Maximum	2345
Sum	1229.79	Sum	1215.395	Sum	197064
Count	168	Count	168	Count	168
Largest (5)	21	Largest (5)	23	Largest (5)	2288.86
Smallest (5)	1.34	Smallest (5)	1	Smallest (5)	57.14
Confidence Level (95.0%)	0.87	Confidence Level (95.0%)	0.96	Confidence Level (95.0%)	103.99

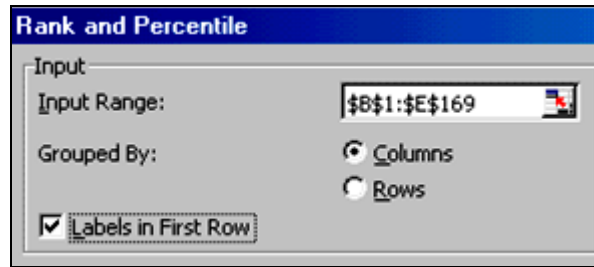
Interpretation of the statistical parameters is discussed in chapter 6, and of Confidence levels is discussed in 7.1.

This tool produces a table that contains the ordinal and percentage rank of each value in a data set. You can analyze the relative standing of values in a data set. The Percentile values can assist in learning about the spread of the series across its range. For a series provides information on the ranges for the lowest 25%, the next 25%, the next 25%, and the

highest 25%.

Go to<sup>14</sup> the menu option TOOLS/DATA ANALYSIS<sup>15</sup>. Select the option “Rank and Percentile.” The dialog is shown in the next figure.

Figure 148: Rank and Percentile tool



The result is reproduced in the next table. Each output table contains four columns:

- The place of the data point in the data series,
- The value of the data (with the label for the series as the label on the output column),
- The rank of the data point within the range, and

<sup>14</sup> I do not supply the sample data for most of the examples in chapter 42 to chapter 46. My experience is that many readers glaze over the examples and do not go through the difficult step of drawing inferences from a result if the sample data results are the same as those in the examples in the book.

<sup>15</sup> If you do not see this option, then use TOOLS / ADD-INS to activate the Add-In for data analysis. Refer to section 41.4.

— The percentage rank of the data point. The columns are sorted in order of ascending rank.

Table 30: Output of the Rank and Percentile tool

<i>Point</i>	<i>s1</i>	<i>Rank</i>	<i>Percent</i>	<i>Point</i>	<i>s2</i>	<i>Rank</i>	<i>Percent</i>
24	21.00	1	96.40%	1	23.00	1	96.40%
48	21.00	1	96.40%	25	23.00	1	96.40%
72	21.00	1	96.40%	49	23.00	1	96.40%
96	21.00	1	96.40%	73	23.00	1	96.40%
120	21.00	1	96.40%	97	23.00	1	96.40%
144	21.00	1	96.40%	121	23.00	1	96.40%
168	21.00	1	96.40%	145	23.00	1	96.40%
23	18.63	8	92.20%	2	20.07	8	92.20%
47	18.63	8	92.20%	26	20.07	8	92.20%
71	18.63	8	92.20%	50	20.07	8	92.20%
95	18.63	8	92.20%	74	20.07	8	92.20%
119	18.63	8	92.20%	98	20.07	8	92.20%
143	18.63	8	92.20%	122	20.07	8	92.20%
167	18.63	8	92.20%	146	20.07	8	92.20%
22	16.53	15	88.00%	3	17.51	15	88.00%
46	16.53	15	88.00%	27	17.51	15	88.00%
70	16.53	15	88.00%	51	17.51	15	88.00%
94	16.53	15	88.00%	75	17.51	15	88.00%
118	16.53	15	88.00%	99	17.51	15	88.00%
142	16.53	15	88.00%	123	17.51	15	88.00%
166	16.53	15	88.00%	147	17.51	15	88.00%

**Interpreting the output:**

The last row's last four columns can be interpreted as—



---

The 147<sup>th</sup> data point in the selected range has a value of 17.51, which gives it rank 15 in the selected range, with 88% of the cells in the range having a value less than or equal to this data point.

10.3

---

## **BIVARIATE RELATIONS– CORRELATION, COVARIANCE**

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### **Correlation analysis**

This tool and its formulas measure the relationship between two data sets that are scaled to be independent of the unit of measurement. The correlation coefficient depicts the basic relationship across two variables: “Do two variables have a tendency to increase together or to change in opposite directions and, if so, by how much?” Bivariate correlations measure the correlation coefficients between two variables at a time, ignoring the effect of all other variables.

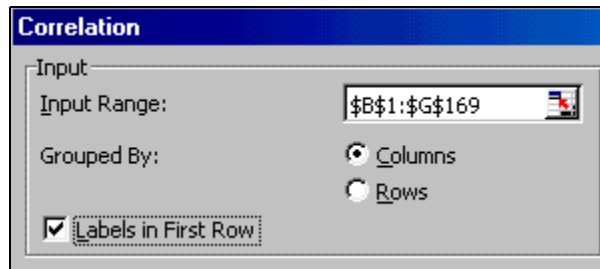
Go to the menu option **TOOLS/DATA ANALYSIS**<sup>16</sup>. Select the option “Correlation.”

Select the “Input Range” — it must have more than one data series.

---

<sup>16</sup> If you do not see this option, then use **TOOLS / ADD-INS** to activate the Add-In for data analysis. Refer to section 41.4.

Figure 149: CORRELATION



The output is reproduced in the next table.

Table 31: Output from Correlation Analysis tool

	<i>s1</i>	<i>s2</i>	<i>x1</i>	<i>x2</i>	<i>x3</i>	<i>x4</i>
<i>s1</i>	1.00000					
<i>s2</i>	-0.75973	1.00000				
<i>x1</i>	-0.13434	0.13226	1.00000			
<i>x2</i>	0.21423	0.47238	0.01658	1.00000		
<i>x3</i>	0.20122	-0.08459	-0.15748	0.14568	1.00000	
<i>x4</i>	-0.13567	0.12935	0.99998	0.01040	-0.15839	1.00000

### Interpreting the output

- A high level of correlation is implied by a correlation coefficient that is greater than 0.5 in absolute terms (that is, greater than 0.5 or less than -0.5).
- A mid level of correlation is implied if the absolute value of the coefficient is greater than 0.2 but less than 0.5.
- A low level of correlation is implied if the absolute value of the coefficient is less than 0.2.

10.3.A

**COVARIANCE TOOL AND FORMULA**

The options are same as for the CORRELATION TOOL. The covariance is dependent on the scale of measurement of the data series. Therefore, there is no standard scale from which to infer if a covariance value is “high” or “low.” Thus, use the correlation tool that provides a uniform scale of “-1 to 1.”

The **coefficient of determination** can be roughly interpreted as the proportion of variance in a series that can be explained by the values of the other series. The coefficient is calculated by squaring the correlation coefficient.





## CHAPTER 11

# HYPOTHESIS TESTING

This chapter teaches:

- Z-TESTING FOR POPULATION MEANS WHEN POPULATION VARIANCES ARE KNOWN
- PAIRED SAMPLE T-TESTS
- T-TESTING MEANS WHEN THE TWO SAMPLES ARE FROM DISTINCT GROUPS
- THE PRETEST— F-TESTING FOR EQUALITY IN VARIANCES
- T-TEST: TWO-SAMPLE ASSUMING UNEQUAL VARIANCES
- T-TEST: TWO-SAMPLE ASSUMING EQUAL VARIANCES
- ANOVA

The statistics Add-In provides some procedures for hypothesis testing.

The “Inverse Functions” in Excel **Cross-reference** (see 7.1) and other statistics software can be used to build Confidence Interval’s that provide the values for the “Critical Regions” for conducting hypothesis tests. The use of the functions opens up a much wider range of possible hypothesis tests limited only by the Inverse functions available in Excel.

I include a set of “testing rules” in several of the examples. These rules will blow your mind — it will make hypothesis testing a readily comprehensible step-by-step process. The rules will assist you in all hypothesis tests— in Excel or otherwise.

---

**This chapter requires the Analysis ToolPak Add-Ins; chapter 9 shows how to learn how to launch the Add-Ins.**

11.1

---

## **Z-TESTING FOR POPULATION MEANS WHEN POPULATION VARIANCES ARE KNOWN**

This tool performs a two-sample Z-test for means with known variances. This tool is used to test hypotheses about the difference between two population means.

### Possible hypothesis for testing

$\mu_1$  is the mean of sample one.  $\mu_2$  is the mean for sample two. The critical regions are based on a 5% significance level (or, equivalently, a 95% Confidence Interval)

#### (a) Two-tailed

The hypothesis

—  $H_0$  (Null Hypothesis):  $\mu_1 - \mu_2 = 1$

—  $H_a$  (Alternate hypothesis):  $\mu_1 - \mu_2 \neq 1$

#### Critical region:

— “Fail to accept” the null hypothesis if the absolute value of the calculated Z is higher than 1.96. Examples of such Z values are: “+2.12” and “-2.12.”

- 
- “Fail to reject” the null hypothesis if the absolute value of the calculated  $Z$  is lower than 1.96. Examples of such  $Z$  values are: “+1.78,” “0.00” and “-1.78.”

In short, if the absolute value of the  $Z$  is higher than 1.96, then one may conclude (with 95% Confidence) that the means of the samples differ by the hypothesized difference.

### (b) One-tailed (left-tail)

The hypothesis:

- $H_0$  (Null Hypothesis):  $\mu_1 - \mu_2 \geq 1$
- $H_a$  (Alternate hypothesis):  $\mu_1 - \mu_2 < 1$  (one-tailed)

### Critical region:

- “Fail to accept” the null hypothesis if the value of the calculated  $Z$  is lower than “-1.64.” Examples of such  $Z$  values are: “-2.12” and “-1.78.”
- “Fail to reject” the null hypothesis if left-tail)

The value of the calculated  $Z$  is greater than “-1.64.” Examples of such  $Z$  values are: “+1.78” and “0.00.”

In short, if the  $Z$  is lower than “-1.64,” then one may conclude (with 95% Confidence) that the means of the samples differ by the hypothesized difference.



(c) One-tailed (right-tail)

The hypothesis:

- $H_0$  (Null Hypothesis):  $\mu_1 - \mu_2 \leq 1$
- $H_a$  (Alternate hypothesis):  $\mu_1 - \mu_2 > 1$  (one-tailed)

Critical region:

- “Fail to accept” the null hypothesis if the value of the calculated  $Z$  is greater than “+1.64.” Examples of such  $Z$  values are: “+2.12” and “+1.78.”
- “Fail to reject” the null hypothesis if the absolute value of the calculated  $Z$  is less than “+1.64.” Examples of such  $Z$  values are: “-1.78” and “0.00.”

In short, if the  $Z$  is greater than “+1.64,” then one may conclude (with 95% Confidence) that the means of the samples differ by the hypothesized difference.

Excel calculates the P or Significance value for each test you run.

- If  $P$  is less than 0.10, then the test is significant at 90% Confidence (equivalently, the hypothesis that the means are equal can be rejected at the 90% level of Confidence). This criterion is considered too “loose” by some.

- If  $P$  is less than 0.05, then the test is significant at 95% Confidence (equivalently, the hypothesis that the means are equal can be rejected at the 95% level of Confidence). This is the standard criterion used.
  
- If  $P$  is less than 0.01, then the test is significant at 99% Confidence (equivalently, the hypothesis that the means are equal can be rejected at the 99% level of Confidence). This is the strictest criterion used.

You should memorize these criteria, as nothing is more helpful in interpreting the output from hypothesis tests (including all the tests intrinsic to every regression, ANOVA and other analysis).

Go to **TOOLS/DATA ANALYSIS**<sup>17</sup>. Select the option “Z-test.” The dialog (user-input form) that opens is shown in the next figure.

Enter the hypothesized mean difference (that is, the Null Hypothesis) into the text-box “Hypothesized Mean Difference.” Enter the variances for the two populations.

---

<sup>17</sup> If you do not see this option, then use **TOOLS / ADD-INS** to activate the Add-In for data analysis. Refer to section 41.4.

Figure 150: Z-test for mean differences when population variance is known

**z-Test: Two Sample for Means**

Input

Variable 1 Range: \$B\$1:\$B\$169

Variable 2 Range: \$C\$1:\$C\$169

Hypothesized Mean Difference: 1

Variable 1 Variance (known): 32

Variable 2 Variance (known): 40

Labels

Alpha: 0.05

The next table shows the result of a Z-test<sup>18</sup>.

Table 32: Output for Z-test for mean differences when population variance is known

Z-test: Two Sample for Means		
	s1 <sup>19</sup>	s2
Mean	7.3202	7.2345
Known Variance	32	40
Observations	168	168
Hypothesized Mean Difference	1.0	
	-1.397	
P (Z <= z) one-tail	0.081	
Z Critical one-tail	1.645	

<sup>18</sup> I do not supply the sample data for most of the examples in chapter 42 to chapter 46. My experience is that many readers glaze over the examples and do not go through the difficult step of drawing inferences from a result if the sample data results are the same as those in the examples in the book.

<sup>19</sup> s1 and s2 are the labels, picked up from the first row in the range b1:b25 and c1:c25.

Z-test: Two Sample for Means		
P (Z<= z) two-tail	0.163	
Z Critical two-tail	1.960	

### Interpreting the output

The P value (that is “P (Z<= or >= z) two-tail”) of 0.081 implies that we fail to reject the null for the two one-tail hypothesis. Moreover,  $Z = -1.397$  implies that we “fail to reject” the null hypothesis because the Z is in the acceptance region (“1.96,” “-1.96”) for the two-tail hypothesis.

The P value (that is “P (Z<>z) two-tail”) of 0.163 implies that we fail to reject the null for the two-tail hypothesis. In addition, if we use a one-tailed (left tail) test, we again fail to reject the null hypothesis because the Z is in the acceptance region (“> -1.645”) for the left-tail hypothesis. If we use a one-tail (right tail) test, we fail to reject the Null because the Z is in the acceptance region (“< +1.645”) for the right-tail hypothesis.

## 11.2

### T-TESTING MEANS WHEN THE TWO SAMPLES ARE FROM DISTINCT GROUPS

#### 11.2.A

#### THE PRETEST— F-TESTING FOR EQUALITY IN VARIANCES

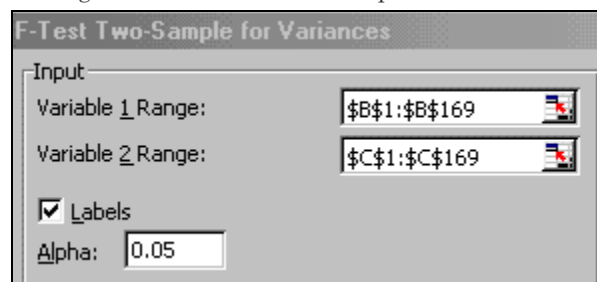
The T-test is used most often to test for differences in means across samples from distinct groups. The respondents in the two samples differ. An example is a pair of samples from two surveys on earnings, one survey in country A and the other in country B. The formula used in estimating the T statistic depends on the equality of variance for the data series

across the two samples. In particular, if the variances of the two samples are unequal the formula takes into account this difference across the samples. An F-test is used to test for unequal variances.

The “F-test Two–sample for Variances” performs a test to compare the variances across two groups of data. Launch the procedure by accessing the menu option TOOLS/DATA ANALYSIS<sup>20</sup> and selecting the “F-test Two–sample for Variances.”

The relevant dialog is reproduced in the next figure.

Figure 151: F-test Two–Sample for Variances



Choose the “alpha” for level of significance. A 0.05 level sets up a 95% confidence test.

The hypothesis:

$$— H_0 \text{ (Null Hypothesis): } \sigma_1^2 — \sigma_2^2 = 0$$

<sup>20</sup> If you do not see this option, then use TOOLS / ADD-INS to activate the Add-In for data analysis. Refer to section 41.4.

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—  $H_a$  (Alternate hypothesis):  $\sigma_1^2 - \sigma_2^2 \neq 0$ , Where  $\sigma_1^2$  is the variance of sample one, and  $\sigma_2^2$  is the variance for sample two.

The F has a one-tail test only.

The next table shows the output of a typical F-test<sup>21</sup>.

Table 33: Output for F-test tool for equality of variances

	s1	s2
Mean	7.3202	7.2345
Variance	32.6754	40.1309
Observations	168	168
Df	167	167
	0.8142	
P (F<= f) one-tail	0.0926	
F Critical one-tail	0.8747	

---

### Interpreting the output

— The row “Variance” shows the estimated variance parameters.

— Inferences from the P value of “0.0926”:

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<sup>21</sup> I do not supply the sample data for most of the examples in chapter 42 to chapter 46. My experience is that many readers glaze over the examples and do not go through the difficult step of drawing inferences from a result if the sample data results are the same as those in the examples in the book.

- If P is less than 0.10, then the test is significant at 90% Confidence (equivalently, the hypothesis that the variances are equal can be rejected at the 90% level of Confidence). The P of 0.0926 implies the test is significant at the 90% Confidence level. Being “significant” implies that the estimated F statistic lies in the critical region and the “null hypothesis cannot be accepted.” You are in the area represented by the alternate hypothesis — the variances are unequal.
  
- If P is less than 0.05, then the test is significant at 95% Confidence (equivalently, the hypothesis that the variances are equal can be rejected at the 95% level of Confidence). The hypothesis cannot be rejected at the 0.05 level of significance.
  
- If P is less than 0.01, then the test is significant at 99% Confidence (equivalently, the hypothesis that the variances are equal can be rejected at the 99% level of Confidence). The hypothesis of equal variances cannot be rejected at the 0.01 level of significance.

The test is significant only at the 0.10 level of significance. The critical estimated F of 0.81 is higher than the critical F of 0.8747 implying that the “null hypothesis of equal variances” cannot be accepted at a 0.05 level of Confidence.

Once you know if the null hypothesis of equal variances can be accepted, you can resolve whether to use the “Two-Sample T-test Assuming Equal Variances” or “Two-Sample T-test Assuming Unequal Variances.”

11.2.B

**T-TEST: TWO-SAMPLE ASSUMING UNEQUAL VARIANCES**

This T-test form assumes that the variances of both ranges of data are unequal. Use this test when the groups under study are distinct. Use a paired test (discussed in the next section) when there is one group before and after a treatment.

Possible hypothesis for testing

$\mu_1$  is the mean of sample one.  $\mu_2$  is the mean for sample two. The critical regions are based on a 5% significance level (or, equivalently, a 95% Confidence Interval)

(a) Two-tailed

The hypothesis

—  $H_0$  (Null Hypothesis):  $\mu_1 - \mu_2 = 0$  (or any non-zero value)

—  $H_a$  (Alternate hypothesis):  $\mu_1 - \mu_2 \neq 0$

Critical region:

— “Fail to accept” the null hypothesis if the absolute value of the calculated T is higher than 1.96. Examples of such Z values are: “+2.12” and “-2.12.”

— “Fail to reject” the null hypothesis if the absolute value of the calculated T is lower than 1.96. Examples of such T values are: “+1.78,” “0.00” and “-1.78.”

In short, if the absolute value of the T is higher than 1.96, then one may conclude (with 95% Confidence) that the means of the samples differ by the hypothesized difference.



(b) One-tailed (left-tail)

The hypothesis:

—  $H_0$  (Null Hypothesis):  $\mu_1 - \mu_2 \geq 0$

—  $H_a$  (Alternate hypothesis):  $\mu_1 - \mu_2 < 0$  (one-tailed)

Critical region:

— “Fail to accept” the null hypothesis if the value of the calculated T is lower than “-1.64.” Examples of such T values are: “-2.12” and “-1.78.”

— “Fail to reject” the null hypothesis if the absolute value of the calculated T is greater than “-1.64.” Examples of such T values are: “+1.78” and “0.00.”

In short, if the T is lower than “-1.64,” one may conclude (with 95% Confidence) that the means of the samples differ by the hypothesized difference.

(c) One-tailed (right-tail)

The hypothesis:

—  $H_0$  (Null Hypothesis):  $\mu_1 - \mu_2 \leq 0$

—  $H_a$  (Alternate hypothesis):  $\mu_1 - \mu_2 > 0$  (one-tailed)

Critical region:

- “Fail to accept” the null hypothesis if the value of the calculated T is greater than “+1.64.” Examples of such T values are: “+2.12” and “+1.78.”
  
- “Fail to reject” the null hypothesis if the absolute value of the calculated T is less than “+1.64.” Examples of such T values are: “-1.78” and “0.00.”

In short, if the T is greater than “+1.64,” then one may conclude (with 95% Confidence) that the means of the samples differ by the hypothesized difference.

Go to the menu option TOOLS/DATA ANALYSIS<sup>22</sup>. Select the option “T-test: Two-Sample Assuming Unequal Variances.” The next table shows a sample output<sup>23</sup> for a T-test assuming unequal variances.

Table 34: Output of Two Sample T-test (assuming unequal variances)

	<i>s1</i>	<i>s2</i>
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<sup>22</sup> If you do not see this option, then use TOOLS / ADD-INS to activate the Add-In for data analysis. Refer to section 41.4.

<sup>23</sup> I do not supply the sample data for most of the examples in chapter 42 to chapter 46. My experience is that many readers glaze over the examples and do not go through the difficult step of drawing inferences from a result if the sample data results are the same as those in the examples in the book.

	<i>s1</i>	<i>s2</i>
Mean	7.32	7.23
Variance	32.68	40.13
Observations	168	168
Hypothesized Mean Difference	5	
Df	331	
T Stat	-7.465	
P (T< = t) one-tail	3.72E-13	
T Critical one-tail	1.649	
P (T< = t) two-tail	7.43E-13	
T Critical two tail	.967	

### Interpreting the output

The row “Mean” shows the estimated means for the two samples  $s1$  and  $s2$ . The next column “Variance” displays the calculated variance for these sample mean values. “Df” shows the “Degree of Freedom.” The degrees of freedom equal the total sample points (the sum of the sample sizes of the two samples) minus the one degree of freedom to account for the one equation (the “hypothesized mean difference” which here is “ $u1 - u2 = 5$ ”). So, degrees of freedom equals “ $168 + 168 - 1 = 331$ ”.

#### (a) Two-tailed

The hypothesis was:

—  $H_0$  (Null Hypothesis):  $u1 - u2 = 5$

—  $H_a$  (Alternate hypothesis):  $u1 - u2 \neq 5$ , where  $u1$  is the mean of sample  $s1$  and  $u2$  the mean of sample  $s2$ .

---

The calculated T statistic is “-7.465.” The P value for the two-tailed test is “3.72 multiplied by the 13th point after the decimal” or “0.000000000000372.” As the P value is less than 0.01, the hypothesis is “significant<sup>24</sup>” at the 99% Confidence level or “alpha = 0.01” level of significance. (The natural extension of this inference is that the hypothesis is significant at the 95% and 90% Confidence levels also.)

The region for the two-tailed test is “> 1.967 or < -1.967.” In this example, the test is significant (at a 0.05 level of significance because the estimated T lies in the critical region. (The estimated T of “-7.465” lies in the region “< -1.967”.)

(b) One-tailed (left-tail)

The hypothesis was:

—  $H_0$  (Null Hypothesis):  $u1 - u2 \geq 5$

—  $H_a$  (Alternate hypothesis):  $u1 - u2 < 5$ , where  $u1$  is the mean of sample  $s1$  and  $u2$  the mean of sample  $s2$ .

The P value for the one-tailed test is “7.45 multiplied by the 13<sup>th</sup> point after the decimal” or “0.000000000000745.” The relevant test here is the left-tail because the T statistic is a negative value. As the P value is less

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<sup>24</sup> If a test is “significant” the implication is a “failure to accept” the null hypothesis. The test T statistic lies in the critical region. In informal terms, the alternate hypothesis is “correct.”

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than 0.01, the hypothesis is “significant” at the 99% Confidence level or “alpha = 0.01” level of significance. (The natural extension of this inference is that the hypothesis is significant at the 95% and 90% Confidence levels also.)

Another way to test the hypothesis is to compare the estimated T statistic to the critical region shown in the column “T Critical one-tail.” The region for the left-tailed test is “< -1.649”. In this example, the test is “significant<sup>25</sup>” at a .05 level of significance because the estimated T lies in the critical region. (The estimated T of “-7.465” lies in the region “< -1.649”.)

(c) One-tailed (right-tail)

The hypothesis was:

—  $H_0$  (Null Hypothesis):  $u1 - u2 \leq 5$

—  $H_a$  (Alternate hypothesis):  $u1 - u2 > 5$ , where  $u1$  is the mean of sample  $s1$  and  $u2$  the mean of sample  $s2$ .

The region for the right-tailed test is “> 1.649”. In this example, the test is not significant because the estimated T does not lie in the critical region. (The estimated T of “-7.465” is not in the region “>1.649”.)

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<sup>25</sup> If a test is “significant” the implication is a “failure to accept” the null hypothesis. The test T statistic lies in the critical region. In informal terms, the alternate hypothesis is “correct.”

11.2.C

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**T-TEST: TWO-SAMPLE ASSUMING EQUAL VARIANCES**

This tool performs a two-sample student's T-test— under the assumption that the variances of both data sets are equal. The hypothesis and interpretation of results is the same as for the Two-Sample Assuming Unequal Variances. (See previous sub-section).

The next table shows the result this type of test<sup>26</sup>.

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**11.3****PAIRED SAMPLE T-TESTS**

This tool performs a paired two-sample T-test to deduce whether the difference between the sample means is statistically distinct from a hypothesized difference. This T-test form does not assume that the variances of both populations are equal. You can use a paired test when there is a natural pairing of observations in the samples, such as when a sample group is tested twice— before and after an experiment. The tested groups form a “Paired Sample” with the same respondents sampled “before” and “after” an event.

Go to the menu option **TOOLS/DATA ANALYSIS**<sup>27</sup>. Select the option “T-

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<sup>26</sup> I do not supply the sample data for most of the examples in chapter 42 to chapter 46. My experience is that many readers glaze over the examples and do not go through the difficult step of drawing inferences from a result if the sample data results are the same as those in the examples in the book.

<sup>27</sup> If you do not see this option, then use **TOOLS / ADD-INS** to activate the Add-In for data analysis. Refer to section 41.4.

test: Two-Sample Assuming Unequal Variances.” The relevant dialog is shown in the next figure.

The range must consist of a single column or row and contain the same number of data points as the first range.

Figure 152: T-test for Paired Samples

The screenshot shows the 't-Test: Paired Two Sample for Means' dialog box. The title bar is blue with white text. The main area is grey and contains the following elements:

- Input** section:
  - Variable 1 Range:
  - Variable 2 Range:
  - Hypothesized Mean Difference:
  - Labels
  - Alpha:

Place the hypothesized difference in means into the checkbox “Hypothesized Mean Difference.” In this example, one is using the hypothesis:

“ $H_0$  (Null Hypothesis): mean difference  $> 5$ ”. See the next figure for an example of setting the hypothesis for testing. Set a hypothesized mean difference of zero to test the standard hypothesis that the “Means for the two groups/samples are statistically different.”

The level of significance for the hypothesis tests should be placed in the checkbox “Alpha.” If you desire a significance level of “alpha = .05” (that is, a Confidence level of 95%), then write in “.05” into the checkbox *Alpha*. The next figure illustrates this.

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### Possible hypothesis for testing

$\mu_1$  is the mean of sample one.  $\mu_2$  is the mean for sample two. The critical regions are based on a 5% significance level (or, equivalently, a 95% Confidence Interval)

#### (a) Two-tailed

The hypothesis

—  $H_0$  (Null Hypothesis):  $\mu_1 - \mu_2 = 0$

—  $H_a$  (Alternate hypothesis):  $\mu_1 - \mu_2 \neq 0$

#### Critical region:

— “Fail to accept” the null hypothesis if the absolute value of the calculated T is higher than 1.96. Examples of such T values are: “+2.12” and “-2.12.”

— “Fail to reject” the null hypothesis if the absolute value of the calculated T is lower than 1.96. Examples of such T values are: “+1.78,” “0.00” and “-1.78.”

In short, if the absolute value of the T is higher than 1.96, then one may conclude (with 95% Confidence) that the means of the samples differ by the hypothesized difference.

#### (b) One-tailed (left-tail)

The hypothesis:

—  $H_0$  (Null Hypothesis):  $\mu_1 - \mu_2 \geq 0$



---

—  $H_a$  (Alternate hypothesis):  $\mu_1 - \mu_2 < 0$  (one-tailed)

Critical region:

— “Fail to accept” the null hypothesis if the value of the calculated T is lower than “-1.64.” Examples of such T values are: “-2.12” and “-1.78.”

— “Fail to reject” the null hypothesis if the absolute value of the calculated T is greater than “-1.64”. Examples of such T values are: “+1.78” and “0.00.”

In short, if the T is lower than “-1.64,” then one may conclude (with 95% Confidence) that the means of the samples differ by the hypothesized difference.

(c) One-tailed (right-tail)

The hypothesis:

—  $H_0$  (Null Hypothesis):  $\mu_1 - \mu_2 \leq 1$

—  $H_a$  (Alternate hypothesis):  $\mu_1 - \mu_2 > 1$  (one-tailed)

Critical region:

— “Fail to accept” the null hypothesis if the value of the calculated T is greater than “+1.64.” Examples of such T values are: “+2.12” and “+1.78.”

— “Fail to reject” the null hypothesis if the absolute value of the calculated T is less than “+1.64.” Examples of such T values are: “-1.78” and “0.00.”

In short, if the T is greater than “+1.64,” then one may conclude (with 95% Confidence) that the means of the samples differ by the hypothesized difference.

Excel calculates the P or Significance value for each test you run.

- If P is less than 0.10, then the test is significant at 90% Confidence (equivalently, the hypothesis that the means are equal can be rejected at the 90% level of Confidence). This criterion is considered too “loose” by some.
  
- If P is less than 0.05, then the test is significant at 95% Confidence (equivalently, the hypothesis that the means are equal can be rejected at the 95% level of Confidence). This is the standard criterion used.
  
- If P is less than 0.01, then the test is significant at 99% Confidence (equivalently, the hypothesis that the means are equal can be rejected at the 99% level of Confidence). This is the strictest criterion used.

You should memorize these criteria, as nothing is more helpful in interpreting the output from hypothesis tests (including all the tests intrinsic to every regression, ANOVA and other analysis). The output for

such a test is shown in the next table<sup>28</sup>.

Table 35: Output from a T-test for Paired Samples. The text in italics has been inserted by the author.

	<i>First sampling</i>	<i>Second sampling</i>	
Mean	152	145	
Variance	126	114	
Observations	44	44	
Pearson Correlation	0.999693		
Hypothesized Mean Difference	5		
Df	43		
T Stat	26.76		<i>26.76 is the <u>T</u> estimated from the data</i>
One-tailed test			
P (T< = t) one-tail	0.00		<i>1.68 is the “T cut-off Critical Value” from <u>T-Tables</u></i>
T Critical one-tail	1.68		
Two-tailed Test			
P (T< = t) two-tail	0.00		<i>2.02 is the “T cut-off Critical Value” from <u>T-Tables</u></i>
T Critical two-tail	2.02		

Interpretation:

One-tailed test		
P (T< = t) one-tail	0.00	<i>Thus, significant at 99%</i>

<sup>28</sup> I do not supply the sample data for most of the examples in chapter 42 to chapter 46. My experience is that many readers glaze over the examples and do not go through the difficult step of drawing inferences from a result if the sample data results are the same as those in the examples in the book.

One-tailed test		
T Critical one-tail (positive for positive tail test, negative for negative tail)	1.68 —1.68	<i>2.02 is the “T cut-off Critical Value” from T-Tables for alpha = 0.05 and Df = 43</i>
Inferential Analysis: — Fail to reject null (1-tailed for null hypothesizing in a negative direction: H <sub>0</sub> (Null Hypothesis): mean<5) — Fail to accept null if H <sub>0</sub> (Null Hypothesis): mean>5.		
Two-tailed Test		
P (T< = t) two-tail	0.00	<i>Thus, significant at 99%</i>
T Critical two-tail (compare absolute value of T- stat from the data with this absolute value)	2.02	<i>This is the “T cut-off Critical Value” from T-Tables for alpha = 0.025 and Df = 43</i>
Inferential Analysis: — For two-tailed test, fail to accept null at 99% Confidence		

11.4

**ANOVA**

This tool performs simple analysis of variance (ANOVA) to test the hypothesis that means from two or more samples are equal (drawn from populations with the same mean). This technique expands on the tests for two means, such as the T-test.

Go to the menu option **TOOLS/DATA ANALYSIS**<sup>29</sup>. Select the option “ANOVA: Single Factor.” The input range must consist of two or more

<sup>29</sup> If you do not see this option, then use **TOOLS / ADD-INS** to activate the Add-In for data analysis. Refer to section 41.4.

adjacent ranges of data arranged in columns or rows. A sample output<sup>30</sup> is shown in the next few tables.

Figure 153: Single Factor ANOVA

The screenshot shows the 'Anova: Single Factor' dialog box. The 'Input' section has 'Input Range' set to '\$A1:\$B169'. Under 'Grouped By', the 'Columns' radio button is selected, and the 'Rows' radio button is unselected. The 'Labels in First Row' checkbox is checked. The 'Alpha' value is set to '0.05'.

Table 36: Output from Single Factor ANOVA — a

ANOVA: Single Factor				
Groups	Count	Sum	Average	Variance
<i>s1</i>	168	1229.8	7.3	32.7
<i>s2</i>	168	1215.4	7.2	40.1

The first table shows some descriptive statistics for the samples.

Table 37: Output from Single Factor ANOVA — b

ANOVA					
Source of Variation	SS	Df	MS	F	P-value

<sup>30</sup> I do not supply the sample data for most of the examples in chapter 42 to chapter 46. My experience is that many readers glaze over the examples and do not go through the difficult step of drawing inferences from a result if the sample data results are the same as those in the examples in the book.

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ANOVA					
Between Groups	0.62	1	0.62	0.017	0.90
Within Groups	12158.65	334	36.403		
Total	12159.27	335			

---

### Interpreting the output

The information on “Between Groups” is derived from the difference in means and variances across the groups. In an ANOVA, the number of groups may exceed two.

— The test is analyzing the variance as measured by the SS “Sum of Squares” of the “dependent” series. The total Sum of Squares is 12159.27. Of this, 0.62 can be explained by the differences across the means of the two groups. The other 12158.65 is explained by the differences across individual values of the “dependent” series.

- Sum of Squares = Sum of Squares for Between Groups + Sum of Squares for Within Groups

— The MS is the “Mean Sum of Squares” and is estimated by dividing the SS by the degrees of freedom. Therefore, the MS for “Between Groups” equals  $(0.62/1) = 0.62$ . (Note that “ANOVA = Analysis of Variance.”) The MS for “Within Groups” equals  $(12158.65/334) = 36.403$ . The MS may be informally interpreted as “Sum of Squares Explained per Degree of Freedom.”

- Mean Sum of Squares = (Sum of Squares)/ (Degrees of Freedom)

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— The ANOVA uses an F-test to determine if “Between Groups” information (the number 0.62 in the column “Between Groups” Source of Variation MS) provides sufficient additional information to improve the ability of the data to explain the variance in the “dependent” series. The ANOVA is asking “Does the *Between Groups* Sum of Squares Explained per Degree of Freedom” divided by the “*Within Groups* Sum of Squares” provide an F that is large enough to justify the statement “The use of Between Groups information explains a statistically significant amount of the Sum of Squares of the dependent series.”

- $F = (\text{Mean Sum of Squares } \textit{Between Groups}) / (\text{Mean Sum of Squares } \textit{Within Groups})$

— All ANOVA tests (including the ANOVA output from a regression) can be interpreted in the same way –

- $F = [ (\text{Increase in ability of model to explain the Sum of Squares}) / (\text{Degrees of Freedom}) ] / [ (\text{Total Sum of Squares}) / (\text{Degrees of Freedom}) ]$







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## CHAPTER 12

### REGRESSION

This chapter discusses the following topics:

- ASSUMPTIONS UNDERLYING REGRESSION MODELS
- CONDUCTING THE REGRESSION

**This chapter requires the Analysis ToolPak Add-Ins; chapter 9 shows how to learn how to launch the Add-Ins.**

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#### 12.1

#### ASSUMPTIONS UNDERLYING REGRESSION MODELS

The field of econometrics uses regression analysis to create quantitative models that can be used to predict the value of a series if one knows the value of several other variables. For example, the wage per hour can be predicted if one knows the values of the variables that constitute the regression equation. This is a big leap of faith from a correlation or Confidence interval estimate. In a correlation, the statistician is not presuming or implying any causality or deduction of causality. On the other hand, regression analysis is used so often (probably even abused) because of its supposed ability to link cause and effect. Skepticism of causal relationships is not only healthy but also important because real power of regression lies in a comprehensive interpretation of the results.

Regression models are used to test the statistical validity of causal relation presumed in theory or hypothesis. Regression can never be divorced from the hypothesis it is testing. The construction of the model has to be based upon the hypothesis, and not on the availability of the data. Therefore, if you believe you have a valid hypothesis, but do not have the correct data series to represent each factor in your hypothesis, the best practice is not running a regression analysis.

On the other hand, the method of throwing in all variables into the model and making the computer select the best model is a misleading technique that sadly has gained popularity because of the belief that the best model is the one that fits the data the best.

The best models can only be a subset of “valid models.” (That is, models that have passed all diagnostic test for presumptions for conforming to the assumptions required by a regression.) Furthermore, note that if the model is shown to “not fit” the data, or the expected relationship between variables is estimated as negligible, you still have valid results. The variance between the hypothesis and the results is always important and can give rise to a new perspective relative to the hypothesis.

The process of interpretation is called inferential analysis and is far more important than the actual number punching. Inferential analysis also includes testing if the data and model have complied with the strong assumptions underlying a regression model.

The very veracity and validity depends upon several diagnostic tests. Unfortunately, many econometricians do not perform the diagnostic testing or simply lie about the inferences and conclusions derived from the model.

Our book “Interpreting Regression Output” provides a summary table (a

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cheat–sheet for you!) that lists the implications of the invalidity of assumptions. (The book can be purchased at <http://www.vjbooks.net>). This summary provides, in one page, what other books have spread out over many chapters. Please use this table as a checklist before you interpret any model. Most statistic professors and textbooks teach the interpretation of regression results before discussing the issue of validity. You will save yourself a lot of grief if you always perform diagnostics after running a regression model.

Once you have a valid model, interpret the results in the logical sequence shown in the table interpreting regression output in our book “Interpreting Regression Output.” This table will provide a framework and flowchart for interpretation thereby enabling a structured and comprehensive inferential analysis.

12.1.A                    **ASSUMPTION 1: THE RELATIONSHIP BETWEEN ANY ONE INDEPENDENT SERIES AND THE DEPENDENT SERIES CAN BE CAPTURED BY A STRAIGHT LINE IN A 2–AXIS GRAPH**

This is also called the assumption of linearity in the regression coefficients. (None of the regression coefficients — the betas — should have an exponential power or any other non— linear transformation.)

12.1.B                    **ASSUMPTION 2: THE INDEPENDENT VARIABLES DO NOT CHANGE IF THE SAMPLING IS REPLICATED**

The independent variables are truly independent— the model assumes is using deviations across the X variables to explain the dependent series. The regression attempts to explain the dependent series’ variations across

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the combination of values of the independent variables.

If repeated samples are used, the model predicts the same predicted dependent series for each combination of X values, but— across the samples— the observed Y may differ across the same combination of X values. (The gap between the predicted and observed Y values is the residual or error.)

12.1.C                    **ASSUMPTION 3:        THE SAMPLE SIZE MUST BE GREATER THAN THE NUMBER OF INDEPENDENT VARIABLES (N SHOULD BE GREATER THAN K-1)**

This assumption ensures that a basic mathematical postulate is adhered to by the regression algorithm. A system of simultaneous equations is only “determined<sup>31</sup>” if the number of equations<sup>32</sup> is greater than the number of unknowns. That is, only if the number of regression coefficients— K minus 1, the subtraction accounting for the coefficient for the intercept).

What information is “known” prior to running the regression?

- All values of the independent variables are known first. In theory, the independent variables are the “experiment.”

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<sup>31</sup> That is, it can be solved to estimate the optimization parameters — the regression coefficients in the case of a regression

<sup>32</sup> The sample size N in the case of a regression

- 
- Once the “experiment” is conducted, the values of the dependent series Y are known. (Not that this “experiment” analogy holds even if the data for the independent and dependent variables are obtained from the same data collection survey.)
  
  - The regression minimizes the sum of the squared residuals, which is the same as minimizing the square of the difference between the observed and the predicted dependent series. The number of residuals equals the number of observations. Thus, the number of equations equals the number of observations.

What information is “unknown” prior to running the regression?

The regression coefficients — the betas — are unknown. Once the regression coefficients are known, one can estimate the predicted dependent variables, errors/residuals, R-square, etc. If X does not vary, then the series cannot have any role in explaining the variation in Y. The number of unknowns equals the number of regression coefficients.

12.1.D

**ASSUMPTION 4: NOT ALL THE VALUES OF ANY ONE  
INDEPENDENT SERIES CAN BE THE SAME**

A model uses the effect of variation in X to explain variation in Y. If X does not vary, then the series cannot have any role in explaining the variation in Y.

Note that the formulas for estimating the regression coefficients — the betas — use the “squared deviations from mean” in the denominator of the formula. If the X values do not vary then all the values equal the mean implying that the “squared deviations from mean” is zero. This will

make the regression coefficient indeterminate because the denominator of the formula equals zero.

12.1.E                    **ASSUMPTION 5:        THE RESIDUAL OR DISTURBANCE  
ERROR TERMS FOLLOW SEVERAL RULES**

This is the most important assumption, and most diagnostic tests are checking for the observance of this assumption. In several textbooks, you will find this assumption broken into parts, but I prefer to list the rules of Assumption 5:

---

**Assumption 5a: The mean/average or expected value of the disturbance equals zero**

If not, then you know that the model has a systemic bias, which makes it inaccurate, especially because one does not typically know what is causing the bias.

---

**Assumption 5b: The disturbance terms all have the same variance**

This assumption is also called homoskedasticity. Given that the expected value of any disturbance equals zero, if one disturbance has a higher variance than the other one, it implies that the observation underlying this high variance should be given less importance because its relative accuracy is suspect. (This is the reason that weighted regression is used to correct for the nonconformity with this rule.)

---

**Assumption 5c: A disturbance term for one observation should have no relation with the disturbance terms for other observations or with any of the independent variables**

The disturbance term must be truly random — one should not be able to predict or guess the value of any disturbance term given any of the information on the model data. The disturbance term is also called the error term. This error is assumed random. If this is not the case, then your model may have failed to capture all the underlying independent variables, incorrectly measured independent variables, or have correlation between successive observations in a series Sorted by one of the independent variables.

Typically, Time Series data series suffers from the problem of disturbance terms being related to the values of previous periods. It is for this reason that times series analysis requires special data manipulation procedures prior to creating any prediction model.

---

**Assumption 5d: There is no specification bias**

This is the most crucial assumption because a mistake in specifying the equation for regression is the responsibility of the statistician. One cannot blame the nature of the data for this problem. One type of specification bias is the use of an incorrect functional form. For example, you have a specification bias if you use a linear function when a logarithmic or exponential function should be used.

The other type of specification bias is when the model does not include a relevant data series. This is the most common type of error of oversight by because of the incorrect habit in creating a hypothesis only after looking at the available data. This approach may result in the exclusion of an important series that may not be in the available data set.



---

Remember that a regression is based on a hypothesis — you always define the hypothesis first. After that, look for data that can capture all of the variables in the hypothesis. If you do not find the data to represent an important factor, then you should not use regression analysis. Another bad habit is the dropping of variables from a model if the coefficient is seen to have no impact on the dependent series. It is better to have an irrelevant or excess series, then to drop a relevant series. In fact, the result that a factor has no impact on the dependent series often provides compelling insight.

---

**Assumption 5e: The disturbance terms have a Normal Density Function**

The use of the F-test for validating the model and the T-tests for validating individual coefficients is predicated on the presumption that the disturbance terms follow a Normal Density Function.

12.1.F

**ASSUMPTION 6: THERE ARE NO STRONG LINEAR  
RELATIONSHIPS AMONG THE INDEPENDENT VARIABLES**

If the relationships are strong, then the regression estimation will not be able to isolate the impact of each independent series. Related to this is another rule: there should be no endogeneity in the model. This means that none of the independent variables should be dependent on other variables. An independent series should not be a function of another independent series.

Every estimate in a regression is not only a point estimate of the parameter of the expected value of the parameter. The regression estimates the expected value (mean) of the parameter, its variance, and its Density Function (the assumption of normality provides the shape of

---

the Density Function). The mean and standard error are estimated by the model. There is a pair of such estimates for each coefficient (each BETA), each disturbance term, and each predicted value of the dependent series.

Note: The dependent series is that whose values you are trying to predict (or whose dependence on the independent variables is being studied). It is also referred to as the “Explained” or “Endogenous” series, or as the “Regressand.”

The independent variables are used to explain the values of the dependent series. The values of the independent variables are not being explained/determined by the model — thus, they are “independent” of the model. The independent variables are also called “Explanatory” or “Exogenous” variables. They are also referred to as “Regressors.”

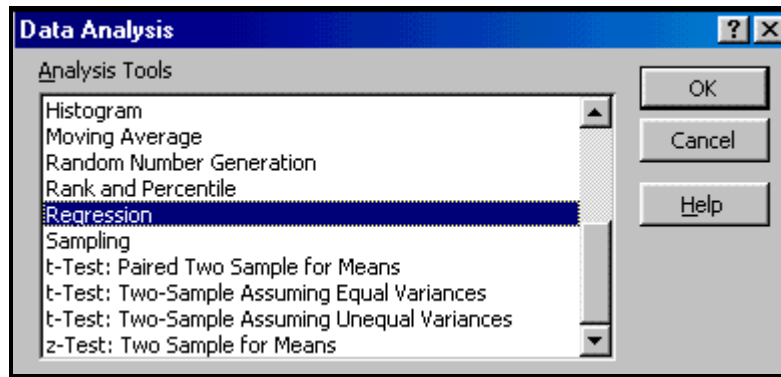
**I do not show the details of regression analysis. Please refer to our book “Interpreting regression Output” available at <http://www.vjbooks.net>.**

Go to the menu option TOOLS/DATA ANALYSIS<sup>33</sup>. Select the option “Regression” as shown in Figure 154.

---

<sup>33</sup> If you do not see this option, then use TOOLS / ADD-INS to activate the Add-In for data analysis. Refer to section 41.4.

Figure 154: Selecting the regression procedure



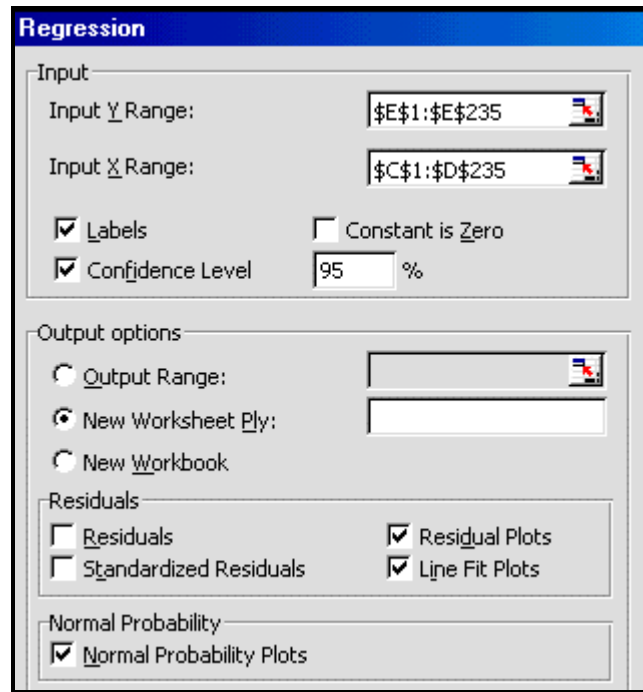
Choose the exact cell references for the Y and X ranges. So do not choose “C:D;” instead, choose C1:D235, as shown in Figure 155.

Other restrictions:

- All the X variables have to be in adjacent columns and
- The data cannot have missing values

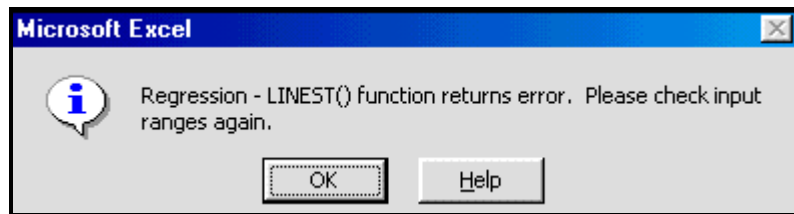
Choose all other options as shown in Figure 155.

Figure 155: The completed Regression dialog



There should be no missing values in the range defined. Otherwise, you get the error message shown in Figure 156.

Figure 156: Error message if you select an incorrect range for the regression



**Warning!** The statistical Add-In provided with Excel has many limitations—it does only a few procedures, has bugs, and cannot handle complex data. (For example, it cannot do a regression if there are any missing values.) Fortunately, some other companies have created Add-Ins that provides comprehensive statistics capabilities. Links to such Add-Ins can be accessed at the URL

<http://www.vjbooks.net/products/publications/Excel/Excel.htm..>

**I do not show the output or its detailed interpretation. Please refer to our book “Interpreting regression Output” available at <http://www.vjbooks.net>.**

A brief summary of interpretation guidelines is presented in the next section.

12.3

### BRIEF GUIDELINE FOR INTERPRETING REGRESSION OUTPUT

Table 38: Interpreting regression output

<i>Name Of Statistic/ Chart</i>	<i>What Does It Measure Or Indicate?</i>	<i>Critical Values</i>	<i>Comment</i>
Sig.-F	Whether the model as a whole is significant. It tests whether R-square is significantly different from zero	<p>– below .01 for 99% confidence in the ability of the model to explain the dependent variable</p> <p>– below .05 for 95% confidence in the ability of the model to explain the dependent variable</p> <p>– below 0.1 for 90% confidence in the ability of the model to explain the dependent variable</p>	<p><u>The first statistic to look for in the output.</u></p> <p>If Sig.-F is insignificant, then the regression as a whole has failed. No more interpretation is necessary (although some disagree on this point). You must conclude that the “Dependent variable cannot be explained by the independent/explanatory variables.” The next steps could be rebuilding the model, using more data points, etc.</p>
RSS, ESS & TSS	The main function of these values lies in calculating test statistics like the	The ESS should be high compared to the TSS (the ratio equals the R-square). Note for	If the R-squares of two models are very similar or rounded off to zero or one, then you might prefer to use the F-test

<i>Name Of Statistic/ Chart</i>	<i>What Does It Measure Or Indicate?</i>	<i>Critical Values</i>	<i>Comment</i>
	F-test, etc.	interpreting the table, column "Sum of Squares":  "Total" =TSS, "Regression" = ESS, and "Residual" = RSS	formula that uses RSS and ESS.
SE of Regression	The standard error of the estimate predicted dependent variable	There is no critical value. Just compare the std. error to the mean of the predicted dependent variable. The former should be small (<10%) compared to the latter.	You may wish to comment on the SE, especially if it is too large or small relative to the mean of the predicted/estimated values of the dependent variable.
-Square	Proportion of variation in the dependent variable that can be explained by the independent variables	Between 0 and 1. A higher value is better.	This often mis-used value should serve only as a summary measure of Goodness of Fit. Do not use it blindly as a criterion for model selection.
Adjusted R-square	Proportion of variance in the dependent variable that can be explained by the independent variables or R-square adjusted for # of independent variables	Below 1. A higher value is better	Another summary measure of Goodness of Fit. Superior to R-square because it is sensitive to the addition of irrelevant variables.
-Ratios	The reliability of our estimate of the individual beta	Look at the p-value (in the column "Sig.") it must be low:  - below .01 for 99% confidence in	For a one-tailed test (at 95% confidence level), the critical value is (approximately) 1.65 for testing if the coefficient is greater than zero and (approximately) -1.65 for

<i>Name Of Statistic/ Chart</i>	<i>What Does It Measure Or Indicate?</i>	<i>Critical Values</i>	<i>Comment</i>
		<p>the value of the estimated coefficient</p> <p>- below .05 for 95% confidence in the value of the estimated coefficient</p> <p>- below .1 for 90% confidence in the value of the estimated coefficient</p>	testing if it is below zero.
Confidence Interval for beta	The 95% confidence band for each beta estimate	The upper and lower values give the 95% confidence limits for the coefficient	Any value within the confidence interval cannot be rejected (as the true value) at 95% degree of confidence
<p>Charts: Scatter of predicted dependent variable and residual (Preferably after standardizing the series)</p> <p>Make a scatter chart manually after running the regression in Excel. **</p>	Mis-specification and/or heteroskedasticity	There should be no discernible pattern. If there is a discernible pattern, then do the RESET and/or DW test for mis-specification or the White's test for heteroskedasticity	Extremely useful for checking for breakdowns of the classical assumptions, i.e. - for problems like mis-specification and/or heteroskedasticity. At the top of this table, we mentioned that the F-statistic is the first output to interpret. Some may argue that the PRED-RESID plot is more important.
Charts: plots of residuals against independent variables. (Preferably after standardizing	Heteroskedasticity	There should be no discernible pattern. If there is a discernible pattern, then perform a formal test.	<p>Common in cross-sectional data.</p> <p>If a partial plot has a pattern, then that variable is a likely candidate for the cause of</p>

<i>Name Of Statistic/ Chart</i>	<i>What Does It Measure Or Indicate?</i>	<i>Critical Values</i>	<i>Comment</i>
the series)  Make a scatter chart manually after running regression**			heteroskedasticity.
Charts: Histograms of residuals. No need to standardize.  Make an area chart after running the regression in Excel**	Provides an idea about the distribution of the residuals	The distribution should look like a normal distribution	A good way to observe the actual behavior of our residuals and to observe any severe problem in the residuals (which would indicate a breakdown of the classical assumptions)

\*\* (a) Estimate the series “predicted” by using the regression formula:

$$\text{Predicted\_Y} = \text{constant} + B_1X_1 + \dots + B_kX_k.$$

(b) Standardize the series of predicted values using the function  
INSERT/ FUNCTION/ STATISTICAL/ STANDARDIZE.

(c) Estimate the residual, by using the formula:

$$\text{Residual} = Y - \text{Predicted\_Y}$$

(d) Standardize the series of residuals using the function INSERT/  
FUNCTION/ STATISTICAL/ STANDARDIZE

(e) make the charts using the standardized series. See book two in this series — *Charting in Excel* — for more on making charts.



12.4

### **BREAKDOWN OF CLASSICAL ASSUMPTIONS: VALIDATION AND CORRECTION**

Basic validation can be conducted using procedures mentioned in the previous table. Excel does not have procedures for more advanced testing. The corrective procedures are not available in Excel.

The validation and corrective procedures are available in Add-Ins for statistics. Links to such Add-Ins can be accessed at the URL <http://www.vjbooks.net/products/publications/Excel/Excel.htm>.

**For more on this topic, please refer to our book “Interpreting regression Output” available at <http://www.vjbooks.net>.**





## **CHAPTER 13**

### OTHER TOOLS FOR STATISTICS

This chapter briefly touches on the following topics:

- SAMPLING ANALYSIS
- RANDOM NUMBER GENERATION
- TIME SERIES
- EXPONENTIAL SMOOTHING, MOVING AVERAGE ANALYSIS

**This chapter requires the Analysis ToolPak Add-Ins; chapter 9 shows how to learn how to launch the Add-Ins.**

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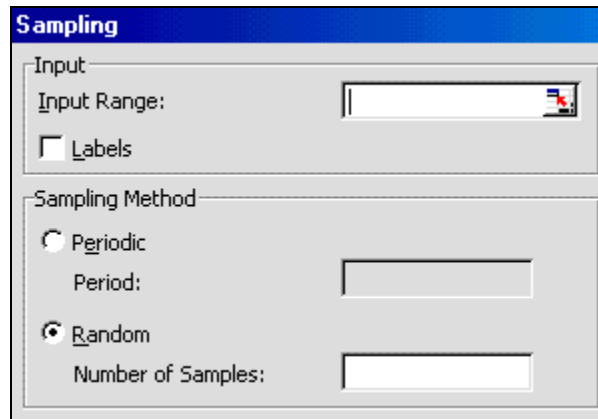
#### 13.1

#### **SAMPLING ANALYSIS**

This tool creates a sample from a population by treating the input range as a population. You can use a representative sample when the population is too large to process or chart. You can also create a sample that contains only values from a particular part of a cycle if you believe that the input data is periodic. Excel draws samples from the first column, then the second column, and so on.

Access the feature through the menu path **TOOLS/DATA ANALYSIS** and choose the procedure “Sampling.”

Figure 157: Sampling



The image shows the 'Sampling' dialog box in Excel. It has a blue title bar with the word 'Sampling' in white. Below the title bar, there are two main sections. The first section is labeled 'Input' and contains an 'Input Range:' text box with a small icon to its right, and a checkbox labeled 'Labels'. The second section is labeled 'Sampling Method' and contains two radio button options: 'Periodic' and 'Random'. The 'Random' option is selected. Below the 'Periodic' option is a text box labeled 'Period:', and below the 'Random' option is a text box labeled 'Number of Samples:'.

*Sampling Method:* choose Periodic or Random to indicate the sampling interval you want.

*Period:* Enter the periodic interval at which you want sampling to take place. The interval value in the input range and every period's value thereafter are copied to the output column.

*Random & Number of Samples:* Number of random values you desire in the output column. Excel draws each value from a random position in the input range. (Consequently, a value may be drawn more than once.)

*Output Range:* Data is written in a single column below the cell.

Note:

If you selected *Periodic*, the number of values in the output table is equal to the number of values in the input range, divided by the sampling rate. If you selected *Random*, the number of values in the output table is equal to the number of samples.

## 13.2

**RANDOM NUMBER GENERATION**

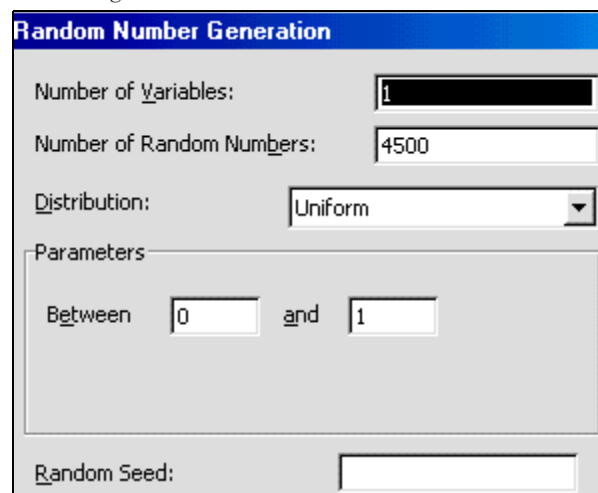
This tool fills a range with independent random numbers drawn from one of several Density Functions.

You can characterize a population with a Probability Density Function.

Select the option TOOLS/DATA ANALYSIS<sup>34</sup> and choose the procedure “Random Number Generation.”

*Number of Variables:* Number of columns of values you want in the output table. If you do not enter a number, all columns in the output will be filled.

Figure 158: Random Number Generator



The image shows a dialog box titled "Random Number Generation". It has a blue header bar. Below the header, there are several input fields: "Number of Variables:" with a text box containing "1"; "Number of Random Numbers:" with a text box containing "4500"; "Distribution:" with a dropdown menu showing "Uniform"; a "Parameters" section with "Between" a text box containing "0" and "and" a text box containing "1"; and "Random Seed:" with an empty text box.

<sup>34</sup> If you do not see this option, then use TOOLS / ADD-INS to activate the Add-In for data analysis. Refer to section 41.4.

*Number of Random Numbers:* Number of data points you want to see. Each point appears in a row of the output table. If you do not enter a number, all rows in the output range will be filled.

*Distribution:* choose the Density Function for defining the criterion for the Random Number generation.

*Parameters:* The base parameters for the generation process using the selected Density Function.

Figure 159: Choice of Density Functions

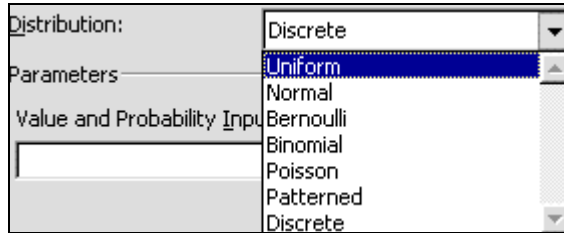
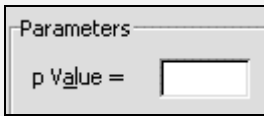
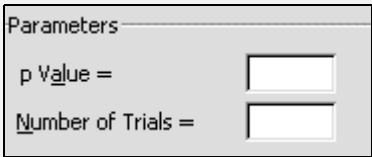
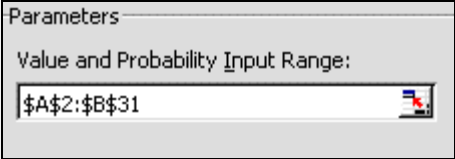
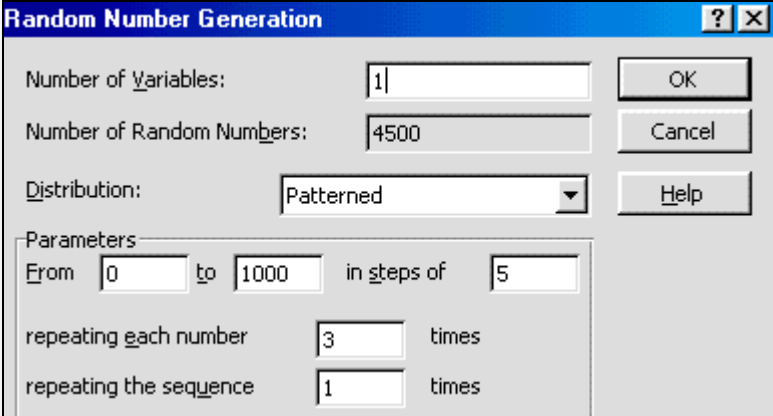
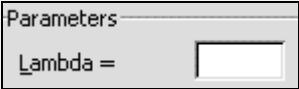


Table 39: Choice of Density Functions

<i>Distribution</i>	<i>Comment on setting parameters for random number generation</i>
Bernoulli	<p>This Density Function is characterized by a probability of success (p value) on any given trial/observation.</p> <p style="text-align: right;">Figure 160: Bernoulli</p> 
Binomial	<p>This Density Function is characterized by a probability of success (p value) in any one trial for a number of trials.</p> <p style="text-align: right;">Figure 161: Binomial</p> 
Discrete	Figure 163: Discrete Or Custom

Distribution	Comment on setting parameters for random number generation																																										
<p>Or Custom Density Function</p>	<p>The range must contain two columns: The left column contains values, and the right column contains probabilities associated with the value in that row. The sum of the probabilities must be 1.</p> <p>Note: You can use the function <code>FREQUENCY (A1, A:A)/count (A:A)</code> to generate the probability you see in column B.</p> <p style="text-align: center;">Figure 162: Parameters</p>  <table border="1" data-bbox="943 285 1261 793" style="margin-left: auto; margin-right: auto;"> <caption>Density Function</caption> <thead> <tr> <th></th> <th>A</th> <th>B</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>x</td> <td>prob_x</td> </tr> <tr> <td>2</td> <td>3000</td> <td>2.9%</td> </tr> <tr> <td>3</td> <td>3030</td> <td>0.8%</td> </tr> <tr> <td>4</td> <td>3060</td> <td>4.5%</td> </tr> <tr> <td>5</td> <td>3091</td> <td>6.7%</td> </tr> <tr> <td>6</td> <td>3121</td> <td>6.6%</td> </tr> <tr> <td>7</td> <td>3153</td> <td>7.2%</td> </tr> <tr> <td>8</td> <td>3184</td> <td>0.1%</td> </tr> <tr> <td>9</td> <td>3216</td> <td>3.0%</td> </tr> <tr> <td>10</td> <td>3248</td> <td>6.5%</td> </tr> <tr> <td>11</td> <td>3280</td> <td>1.0%</td> </tr> <tr> <td>12</td> <td>3313</td> <td>1.8%</td> </tr> <tr> <td>13</td> <td>3346</td> <td>0.3%</td> </tr> </tbody> </table>		A	B	1	x	prob_x	2	3000	2.9%	3	3030	0.8%	4	3060	4.5%	5	3091	6.7%	6	3121	6.6%	7	3153	7.2%	8	3184	0.1%	9	3216	3.0%	10	3248	6.5%	11	3280	1.0%	12	3313	1.8%	13	3346	0.3%
	A	B																																									
1	x	prob_x																																									
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5	3091	6.7%																																									
6	3121	6.6%																																									
7	3153	7.2%																																									
8	3184	0.1%																																									
9	3216	3.0%																																									
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11	3280	1.0%																																									
12	3313	1.8%																																									
13	3346	0.3%																																									
<p>Normal</p>	<p>This Density Function is characterized by a mean and a standard deviation.</p>																																										
<p>Patterned</p>	<p style="text-align: center;">Figure 164: Patterned</p> 																																										
<p>Poisson</p>	<p>This Density Function is characterized by a value lambda, equal to (1/mean).</p> <p style="text-align: center;">Figure 165: Poisson</p> 																																										



<i>Distribution</i>	<i>Comment on setting parameters for random number generation</i>
Uniform	This distributing is characterized by lower and upper bounds. Excel draws variables from all values in the range. The probability of drawing a value is equal for all values in the range.

### Exponential Smoothing

This tool and its formula predict a value based on the forecast for the prior period, adjusted for the error in that prior forecast. The tool uses the smoothing constant alpha, the magnitude of which determines how strongly forecasts respond to errors in the prior forecast.

Using the mouse, select the menu path **TOOLS/DATA ANALYSIS**<sup>35</sup> and choose the procedure “Exponential Smoothing.”

*Damping:* The factor you want to use as the exponential smoothing constant. The damping factor is a corrective factor that minimizes the instability of data collected across a population.

The default value for the damping factor is 0.3. Values of 0.2 to 0.3 are reasonable smoothing constants. These values indicate that the current forecast should be adjusted 20 to 30 percent for error in the prior forecast.

---

<sup>35</sup> If you do not see this option, then use **TOOLS / ADD-INS** to activate the Add-In for data analysis. Refer to section 41.4.

---

Larger constants yield a faster response but can produce erratic projections. Smaller constants can result in long lags for forecast values.

Figure 166: Exponential Smoothing

The screenshot shows the 'Exponential Smoothing' dialog box. It has a blue title bar with the text 'Exponential Smoothing'. Below the title bar, there are two main sections. The first section is labeled 'Input' and contains three items: 'Input Range:' followed by a text box and a small icon with a red cross; 'Damping factor:' followed by a text box; and a checkbox labeled 'Labels'. The second section is labeled 'Output options' and contains four items: 'Output Range:' followed by a text box and a small icon with a red cross; 'New Worksheet Ply:' followed by a text box; 'New Workbook' (which is disabled and shown in a lighter color); and two checkboxes, 'Chart Output' and 'Standard Errors'.

*Data Requirement:* A single column or row with four or more cells with valid data.

*Output:* The output range must be on the same worksheet as the data in the input range. Enter the range reference for the upper—left cell of the output table (for example, “AD4”). You can obtain a column of Standard Errors by selecting the option “Standard Errors.” If you want to chart the procedure's output — the actual values and forecasts —, select the option “Chart Output.”

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## Moving Average analysis

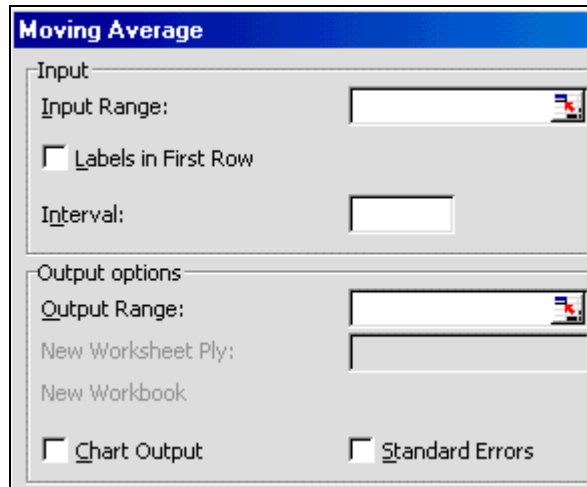
This tool projects values in the forecast period based on “the average value of the series over a specific number of preceding periods.” A moving average provides trend information that a simple average of all historical data would mask.

---

Select the option TOOLS/DATA ANALYSIS<sup>36</sup> and choose the procedure “Moving Average.”

*Interval:* Number of values you want to include in the moving average. The default is three.

Figure 167: Moving Average



Moving Average	
Input	
Input Range:	<input type="text"/>
<input type="checkbox"/> Labels in First Row	
Interval:	<input type="text"/>
Output options	
Output Range:	<input type="text"/>
New Worksheet Ply:	<input type="text"/>
New Workbook	<input type="text"/>
<input type="checkbox"/> Chart Output	<input type="checkbox"/> Standard Errors

*Data Requirement:* A single column or row with four or more cells with valid data.

*Output:* The output range must be on the same worksheet as the data in the input range. Enter the range reference for the upper-left cell of the output table (for example, “AD4”). You can obtain a column of Standard Errors by selecting the option “Standard Errors.” If you want to chart the procedure's output — the actual values and forecasts —, select the option

---

<sup>36</sup> If you do not see this option, then use TOOLS / ADD-INS to activate the Add-In for data analysis. Refer to section 41.4.

“Chart Output.”



---

## CHAPTER 14

# THE SOLVER TOOL FOR CONSTRAINED LINEAR OPTIMIZATION

This chapter teaches:

- DEFINING THE OBJECTIVE FUNCTION (CHOOSING THE OPTIMIZATION CRITERION)
- ADDING CONSTRAINTS
- OPTIONS

---

14.1

### DEFINING THE OBJECTIVE FUNCTION (CHOOSING THE OPTIMIZATION CRITERION)

The problem of constrained optimization:

For example,

*Maximize/Minimize* *lother* (over the choice parameters  $X_c \dots$ )  $Y = f(X_1, X_2 \dots)$

**Subject to** the inequality constraints:-

$C_1 = \dots C_2 \geq \dots$  ,  $C_3 \leq \dots$

The Add-In “Solver” can solve such models. In the Solver dialog (user-input form), the options equate with the function above. The “mapping” of the dialog to different parts of the optimization function is shown in the next table.

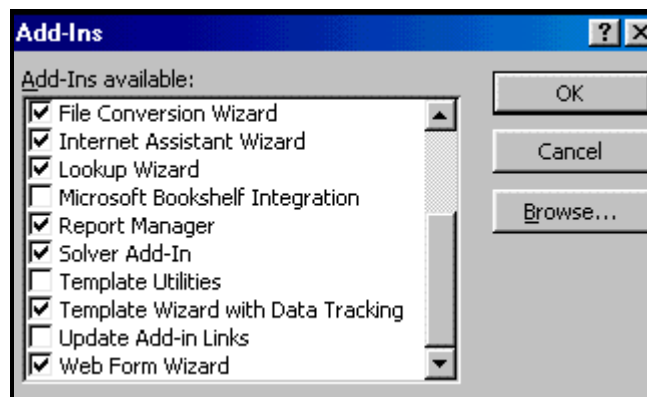
Table 40: The “Solver”

<i>Option in the Solver dialog ....</i>	<i>Equate to the following part of the optimization function...</i>
Equal to:”	The optimization function
Set Target Cell”	Function that needs to be optimized
By Changing Cells”	The choice parameters $X_c$ ....
Subject to the Constraints”	The constraints $C_1, C_2, \dots$

The Solver permits constraints of inequality. This makes the solver extremely powerful.

Choose the menu option TOOLS/ADD-INS. Choose the Add-In “Solver” as shown in Figure 168. Execute the dialog by clicking on the button OK.

Figure 168: Selecting the Solver Add-In



You have activated the “Analysis ToolPak.” If you go to the menu TOOLS, you will see the option “SOLVER”— this option was not there before you accessed the Add-In. Please define a sample problem and try it on an Excel workbook<sup>37</sup>.

Access the feature through the menu path TOOLS/SOLVER. The dialog shown in Figure 169 opens. The “Target Cell” contains the formula for the function you are attempting to optimize.

The “Equal to” area is where you choose the optimization criterion—

— Maximization (Max)

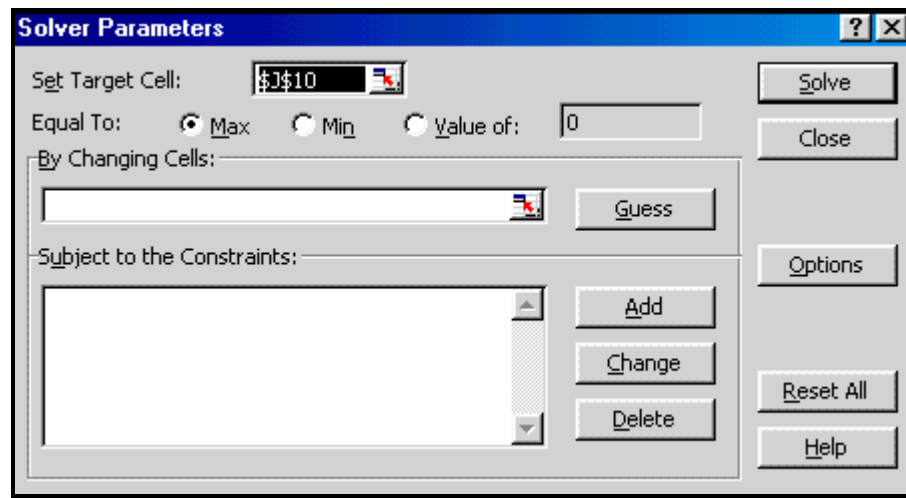
— Minimization (Min)

---

<sup>37</sup> I do not supply the sample data for most of the examples in chapter 42 to chapter 46. My experience is that many readers glaze over the examples and do not go through the difficult step of drawing inferences from a result if the sample data results are the same as those in the examples in the book.



Figure 169: Setting the target cell

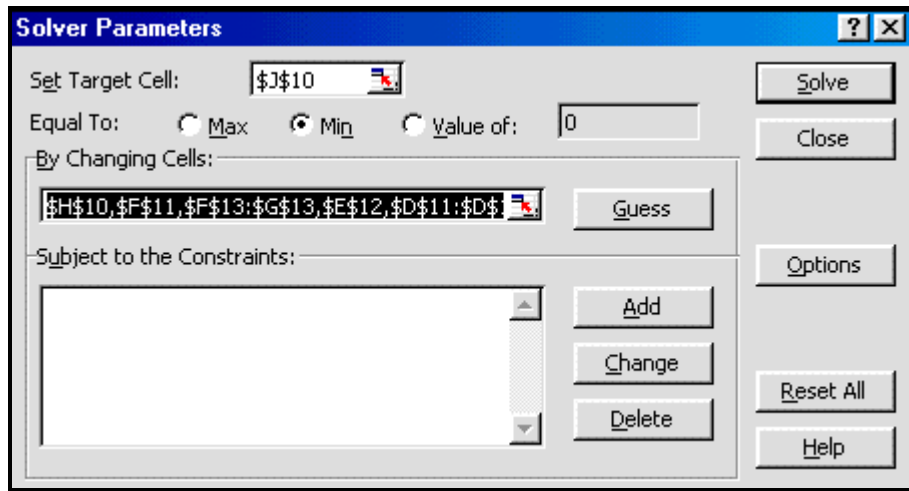


The choice parameters are the numbers the algorithm plays around with to find the max/min.

You have to tell Excel about the cells that contain these parameters. One can do it manually, or, an easier option is to click on the button “Guess.”

Excel automatically chooses all the cell references for use in the formula in J10 (the target cell/objective function). This is illustrated in Figure 170.

Figure 170: Selecting the criterion for optimization



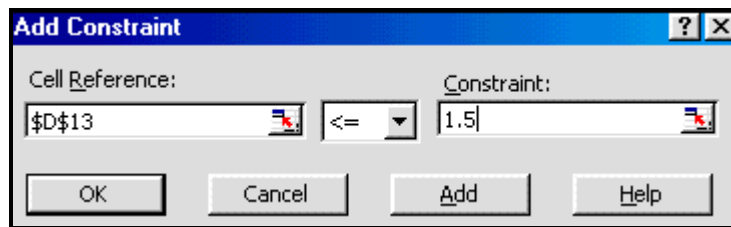
## 14.2

**ADDING CONSTRAINTS**

The optimization function has been defined, as have the “choice parameters.” At this stage, you have to add the constraints.

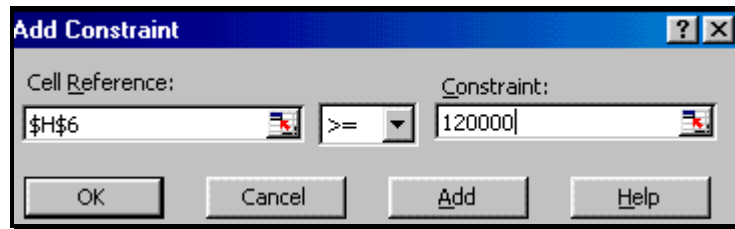
Click on the button “Add” and write in a constraint as shown in Figure 171.

Figure 171: The first constraint



After defining the first constraint, click on the button “Add” (see Figure 171.) Write the second constraint— see Figure 172.

Figure 172: The second constraint

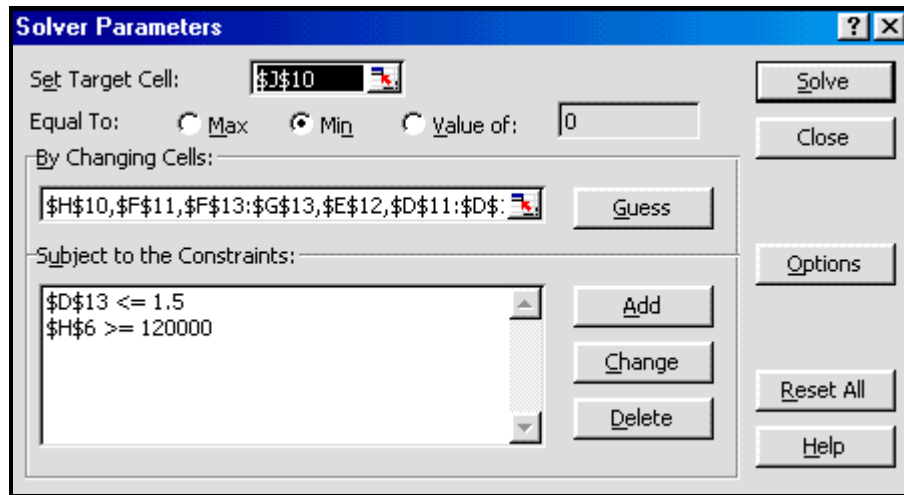


Continue with constraint definitions. After defining the last constraint, execute the dialog by clicking on the button OK (see Figure 172).

Note:

The constraints are shown in the area “Subject to the Constraints” as shown in Figure 173.

Figure 173: The constraints for the Solver



## 14.3

**CHOOSING ALGORITHM OPTIONS**

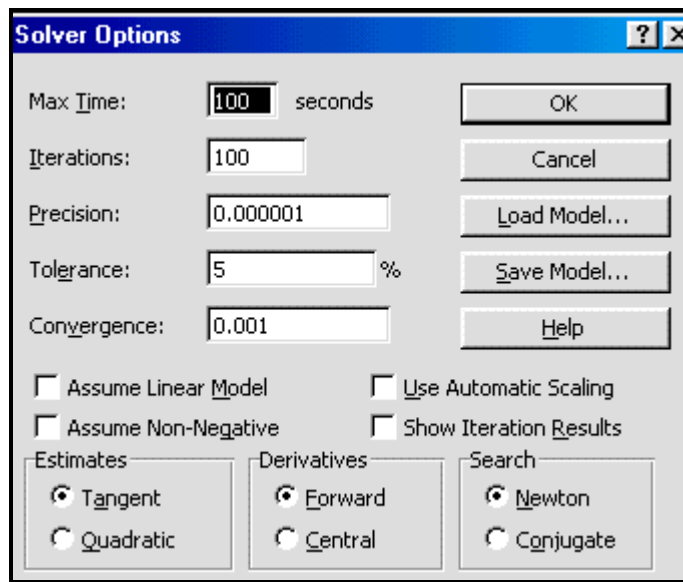
You need to choose the options for the analysis. So, click on the button “Options.” The dialog shown in Figure 174 opens.

---

You may want to increase the iterations to 10,000. If you want to relax the requirements for preciseness, increase the value of “Precision” by removing some post-decimal zeros.

“Save Model” is used to save each optimization model. You can define several optimization problems in one workbook. The other options are beyond the scope of this book. Click on the button “Continue.”

Figure 174: Options in the Solver Add-In



---

## Running the Solver

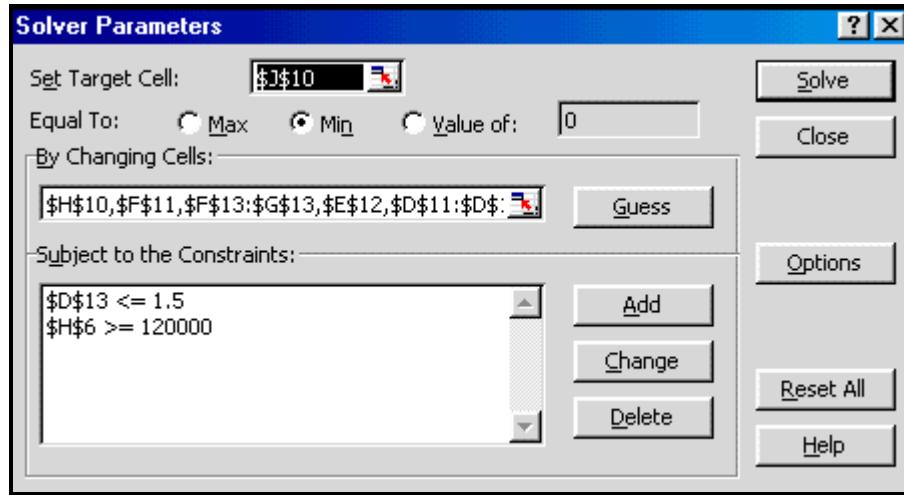
Execute the procedure by clicking on the button “Solve.”

The following output can be read from the spreadsheet.

- the optimized value of the Objective Function (that is, the value of the formula in the cell defined in the box “Set Target Cell”)

- is the combination of the choice variables (that is, those whose value is obtained from the cells defined in the dialog area “By Changing Cells”)

Figure 175: The completed constrained optimization dialog



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