
Guide to Using

@RISK

Risk Analysis and Simulation Add-In for Microsoft® Excel

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Welcome

@RISK for Microsoft Excel

Welcome to @RISK, the revolutionary software system for the analysis of business and technical situations impacted by risk! The techniques of Risk Analysis have long been recognized as powerful tools to help decision-makers successfully manage situations subject to uncertainty. Their use has been limited because they have been expensive, cumbersome to use, and have substantial computational requirements. However, the growing use of computers in business and science has offered the promise that these techniques can be commonly available to all decision-makers.

That promise has been finally realized with @RISK (pronounced "at risk") — a system which brings these techniques to the industry standard spreadsheet package, Microsoft Excel. With @RISK and Excel any risky situation can be modeled, from business to science and engineering. You are the best judge of what your analysis needs require, and @RISK, combined with the modeling capabilities of Excel, allows you to design a model which best satisfies those needs. Anytime you face a decision or analysis under uncertainty, you can use @RISK to improve your picture of what the future could hold.

Why You Need Risk Analysis and @RISK

Traditionally, analyses combine single "point" estimates of a model's variables to predict a single result. This is the standard Excel model — a spreadsheet with a single estimate of results. Estimates of model variables must be used because the values which actually will occur are not known with certainty. In reality, however, many things just don't turn out the way that you have planned. Maybe you were too conservative with some estimates and too optimistic with others. The combined errors in each estimate often lead to a real-life result that is significantly different from the estimated result. The decision you made based on your "expected" result might be the wrong decision, and a decision you never would have made if you had a more complete picture of all possible outcomes. Business decisions, technical decisions, scientific decisions ... all use estimates and assumptions. With @RISK, you can explicitly include the uncertainty present in your estimates to generate results that show all possible outcomes.

@RISK uses a technique called "simulation" to combine all the uncertainties you identify in your modeling situation. You no longer are forced to reduce what you know about a variable to a single number. Instead, you include all you know about the variable, including its full range of possible values and some measure of likelihood of occurrence for each possible value. @RISK uses all this information, along with your Excel model, to analyze every possible outcome. It's just as if you ran hundreds or thousands of "what-if" scenarios all at once! In effect, @RISK lets you see the full range of what could happen in your situation. It's as if you could "live" through your situation over and over again, each time under a different set of conditions, with a different set of results occurring.

All this added information sounds like it might complicate your decisions, but in fact, one of simulation's greatest strengths is its power of communication. @RISK gives you results that graphically illustrate the risks you face. This graphical presentation is easily understood by you, and easily explained to others.

So when should you use @RISK? Anytime you make an analysis in Excel that could be affected by uncertainty, you can and should use @RISK. The applications in business, science and engineering are practically unlimited and you can use your existing base of Excel models. An @RISK analysis can stand alone, or be used to supply results to other analyses. Consider the decisions and analyses you make every day! If you've ever been concerned with the impact of risk in these situations, you've just found a good use for @RISK!

Modeling Features

As an "add-in" to Microsoft Excel, @RISK "links" directly to Excel to add Risk Analysis capabilities. The @RISK system provides all the necessary tools for setting up, executing and viewing the results of Risk Analyses. And @RISK works in a style you are familiar with — Excel style menus and functions.

@RISK Functions

@RISK allows you to define uncertain cell values in Excel as probability distributions using functions. @RISK adds a set of new functions to the Excel function set, each of which allows you to specify a different distribution type for cell values. Distribution functions can be added to any number of cells and formulas throughout your worksheets and can include arguments which are cell references and expressions — allowing extremely sophisticated specification of uncertainty. To help you assign distributions to uncertain values, @RISK includes a graphical pop-up window where distributions can be previewed and added to formulas.

Available Distribution Types

The probability distributions provided by @RISK allow the specification of nearly any type of uncertainty in cell values in your spreadsheet. A cell containing the distribution function `NORMAL(10,10)`, for example, would return samples during a simulation drawn from a normal distribution (mean = 10, standard deviation = 10). Distribution functions are only invoked during a simulation — in normal Excel operations, they show a single cell value — just the same as Excel before @RISK. Available distribution types include:

<i>Beta</i>	<i>General</i>	<i>Pareto2</i>
<i>BetaGeneral</i>	<i>Geometric</i>	<i>Pearson V</i>
<i>Beta-Subjective</i>	<i>Histogram</i>	<i>Pearson VI</i>
<i>Binomial</i>	<i>Hypergeometric</i>	<i>PERT</i>
<i>Chi-Square</i>	<i>Inverse Gaussian</i>	<i>Poisson</i>
<i>Cumulative</i>	<i>IntUniform</i>	<i>Rayleigh</i>
<i>Discrete</i>	<i>Logistic</i>	<i>Student's t</i>
<i>Discrete Uniform</i>	<i>Log-Logistic</i>	<i>Triangular</i>
<i>Error Function</i>	<i>Lognormal</i>	<i>Trigen</i>
<i>Erlang</i>	<i>Lognormal2</i>	<i>Uniform</i>
<i>Exponential</i>	<i>Negative Binomial</i>	<i>Weibull</i>
<i>Extreme Value</i>	<i>Normal</i>	
<i>Gamma</i>	<i>Pareto</i>	

All distributions may be truncated to allow only samples within a given range of values within the distribution. Also, many distributions can also use alternate percentile parameters. This allows you to specify values for specific percentile locations of an input distribution as opposed to the traditional arguments used by the distribution.

@RISK Simulation Analysis

@RISK has sophisticated capabilities for specifying and executing simulations of Excel models. Both Monte Carlo and Latin Hypercube sampling techniques are supported, and distributions of possible results may be generated for any cell or range of cells in your spreadsheet model. Both simulation options and the selection of model outputs are entered with Windows style menus, dialog boxes and use of the mouse.

Graphics

High resolution graphics are used to present the output distributions from your @RISK simulations. Histograms, cumulative curves, and summary graphs for cell ranges all lead to a powerful presentation of results. And all graphs may be displayed in Excel for further enhancement and hard copy. An essentially unlimited number of output distributions may be generated from a single simulation — allowing for the analysis of even the largest and most complex spreadsheets!

**Advanced
Simulation
Capabilities**

The options available for controlling and executing a simulation in @RISK are among the most powerful ever available. They include:

- *Latin Hypercube or Monte Carlo sampling*
- *Any number of iterations per simulation*
- *Any number of simulations in a single analysis*
- *Animation of sampling and recalculation of the spreadsheet*
- *Seeding the random number generator*
- *Real time results and statistics during a simulation*

**High Resolution
Graphic
Displays**

@RISK graphs a probability distribution of possible results for each output cell selected in @RISK. @RISK graphics include:

- *Relative frequency distributions and cumulative probability curves*
- *Summary graphs for multiple distributions across cell ranges (for example, a worksheet row or column)*
- *Statistical reports on generated distributions*
- *Probability of occurrence for target values in a distribution*
- *Export of graphics as Windows metafiles for further enhancement*

**Product
Execution
Speed**

Execution time is of critical importance because simulation is extremely calculation intensive. @RISK is designed for the fastest possible simulations through the use of advanced sampling techniques.

Table of Contents

Chapter 1: Getting Started	1
Introduction	3
Installation Instructions	7
Quick Start.....	11
 Chapter 2: An Overview to Risk Analysis	 15
Introduction	17
What Is Risk?	19
What Is Risk Analysis?	23
Developing an @RISK Model.....	25
Analyzing a Model with Simulation.....	27
Making a Decision: Interpreting the Results.....	29
What Risk Analysis Can (Cannot) Do	33
 Chapter 3: Upgrade Guide	 35
Introduction	37
New @RISK Model Window	39
New @RISK Add-in Features	43
New @RISK Results Window	45
New Features in @RISK 4.5 vs @RISK 4.0.....	49

Chapter 4: Getting to Know @RISK	57
A Quick Overview to @RISK	59
Setting Up and Simulating an @RISK Model.....	69
Chapter 5: @RISK Modeling Techniques	91
Introduction	93
Modeling Interest Rates and Other Trends	95
Projecting Known Values into the Future.....	97
Modeling Uncertain or "Chance" Events	99
Oil Wells and Insurance Claims	101
Adding Uncertainty Around a Fixed Trend.....	103
Dependency Relationships	105
Sensitivity Simulation	107
Simulating a New Product: The Hippo Example	109
Finding Value at Risk (VAR) of a Portfolio.....	119
Simulating the NCAA Tournament	123
Chapter 6: Distribution Fitting	127
Overview	129
Define Input Data.....	131
Select Distributions To Fit.....	135
Run The Fit.....	139
Interpret the Results	143
Using the Results of a Fit	151

Chapter 7: @RISK Reference Guide	153
Introduction	161
Reference: @RISK Icons.....	163
Reference: @RISK Add-In Menu Commands	173
File Menu	175
Model Menu	177
Simulate Menu	189
Results Menu	203
Options Menu	207
Advanced Analyses Menu	209
Goal Seek.....	211
Stress Analysis	217
Advanced Sensitivity Analysis.....	229
Reference: @RISK Model Window Commands	245
File Menu	247
Edit Menu.....	249
View Menu	251
Insert Menu.....	253
Simulation Menu	261
Model Menu	263
Correlation Menu	273
Fitting Menu.....	281
Graph Menu	307

Artist Menu.....	315
Window Menu	321
Help Menu	323
Reference: @RISK Results Window Commands	325
File Menu.....	327
Edit Menu	329
View Menu.....	333
Insert Menu	335
Simulation Menu.....	351
Results Menu	353
Graph Menu	359
Window Menu	377
Help Menu	379
Reference: @RISK Functions	381
Introduction	381
Reference: Distribution Functions	399
Reference: Distribution Property Functions	425
Reference: Output Functions.....	435
Reference: Statistics Functions	437
Reference: Supplemental Functions.....	443
Reference: Graphing Function	445
Reference: @RISK Macros	447
Overview	447

Using VBA to Modify @RISK Settings and Enter Outputs	449
Using VBA to Run Simulations, Get Results and Generate Reports	451
Using VBA to Run Advanced Analyses.....	453
Appendix A: Sampling Methods	455
What is Sampling?.....	455
Appendix B: Using @RISK With Other DecisionTools®	461
The DecisionTools Suite	461
Palisade's DecisionTools Case Study	463
Introduction to TopRank®	467
Using @RISK with TopRank	471
Introduction to PrecisionTree™	475
Using @RISK with PrecisionTree.....	479
Appendix C: Glossary	483
Appendix D: Recommended Readings	489
Readings by Category	489

Chapter 1: Getting Started

Introduction	3
About This Version	3
Working with your Operating Environment	4
If You Need Help	4
@RISK System Requirements.....	6
Installation Instructions	7
General Installation Instructions	7
The DecisionTools Suite.....	8
Setting Up the @RISK Icons or Shortcuts.....	9

Introduction

This introduction describes the contents of your @RISK package and shows you how to install @RISK and attach it to your copy of Microsoft Excel 97 for Windows or higher.

Checking Your Package

Your @RISK package should contain:

The @RISK User's Guide (this book) with:

- *Getting Started*
- *Overview to Risk Analysis and @RISK*
- *Upgrade Guide*
- *Getting to Know @RISK*
- *@RISK Modeling Techniques*
- *Distribution Fitting*
- *@RISK Reference Guide*
- *Technical Appendices*

The @RISK CD-ROM including:

- *@RISK Program*
- *@RISK Tutorial*

The @RISK Licensing Agreement

A complete listing of all files contained on the @RISK CD is contained in the file INSTALL.LOG found in the DTOOLS\RISK45 directory on your hard disk.

If your package is not complete, please call your @RISK dealer or supplier or contact Palisade Corporation directly at (607) 277-8000. If you want to install @RISK from diskettes, please contact Palisade Corporation.

About This Version

This version of @RISK can be installed as a 32-bit program for Microsoft Excel 97 or higher.

Working with your Operating Environment

This User's Guide assumes that you have a general knowledge of the Windows operating system and Excel. In particular:

- *You are familiar with your computer and using the mouse.*
- *You are familiar with terms such as icons, click, double-click, menu, window, command and object.*
- *You understand basic concepts such as directory structures and file naming.*

If You Need Help

Technical support is provided free of charge for all registered users of @RISK with a current maintenance plan, or is available on a per incident charge. To ensure that you are a registered user of @RISK, **please register online at www.palisade.com/html/register.html.**

If you contact us by telephone, please have your serial number and User's Guide ready. We can offer better technical support if you are in front of your computer and ready to work.

Before Calling

Before contacting technical support, please review the following checklist:

- *Have you referred to the on-line help?*
- *Have you checked this User's Guide and reviewed the on-line multimedia tutorial?*
- *Have you read the README.WRI file? It contains current information on @RISK that may not be included in the manual.*
- *Can you duplicate the problem consistently? Can you duplicate the problem on a different computer or with a different model?*
- *Have you looked at our site on the World Wide Web? It can be found at **<http://www.palisade.com>**. Our Web site also contains the latest FAQ (a searchable database of tech support questions and answers) and @RISK patches in our Technical Support section. We recommend visiting our Web site regularly for all the latest information on @RISK and other Palisade software.*

Contacting Palisade

Palisade Corporation welcomes your questions, comments or suggestions regarding @RISK. Contact our technical support staff using any of the following methods:

- *E-mail us at tech-support@palisade.com.*
- *Telephone us at (607) 277-8000 any weekday from 9:00 AM to 5:00 PM, EST. Press 2 on a touch-tone phone to reach technical support.*
- *Fax us at (607) 277-8001.*
- *Mail us a letter at:*

**Technical Support
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- *E-mail us at tech-support@palisade-europe.com.*
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- *Fax us at +44 (0)207 375 1229 (UK).*
- *Mail us a letter at:*

**Palisade Europe
Technical Support
The Blue House, Unit 1
30 Calvin Street
London E1 6NW UK**

Regardless of how you contact us, please include the product name, exact version and serial number. The exact version can be found by by selecting the Help About command on the @RISK menu in Excel.

**Student
Versions**

Telephone support is not available with the student version of @RISK. If you need help, we recommend the following alternatives:

- *Consult with your professor or teaching assistant.*
- *Log-on to our site on the World Wide Web for answers to frequently asked questions.*
- *Contact our technical support department via e-mail or fax.*

@RISK System Requirements

System requirements for @RISK 4.5 for Microsoft Excel for Windows include:

- *Pentium PC or faster with a hard disk.*
- *Microsoft Windows 95 or higher or Windows NT 4.0 or higher.*
- *32 MB installed memory.*
- *Microsoft Excel Version 97 or higher.*

Installation Instructions

General Installation Instructions

The Setup program copies the @RISK system files into a directory you specify on your hard disk. Setup asks you for the location of the Excel directory on your hard disk, so please note this information before running Setup. Setup and @RISK require Microsoft Windows to run, so be sure to start Windows before running these programs.

To run the Setup program in Windows 95 or higher:

- 1) *Insert the @RISK CD-ROM in your CD-ROM drive*
- 2) *Click the Start button, click Settings and then click Control Panel*
- 3) *Double-click the Add/Remove Programs icon*
- 4) *On the Install/Uninstall tab, click the Install button*
- 5) *Follow the Setup instructions on the screen*

If you encounter problems while installing @RISK, verify that there is adequate space on the drive to which you're trying to install. After you've freed up adequate space, try rerunning the installation.

Within 30 days of installing @RISK you need to authorize your copy of @RISK.

Authorizing Your Copy of @RISK



Authorization can be done over the Internet by clicking the **Authorize Now** button and following the prompts on the screen. Alternatively, you can contact Palisade or Palisade Europe during normal business hours and authorize your copy of @RISK over the phone.

An authorized copy of @RISK is licensed for use on a single computer only. If you wish to move your copy of @RISK to a different computer, please contact Palisade for instructions.

**Removing
@RISK from
Your Computer**

Setup creates the file INSTALL.LOG in your @RISK directory. This file lists the names and locations of all installed files. If you wish to remove @RISK from your computer, use the Control Panel's Add/Remove Programs utility and select the entry for @RISK.

The DecisionTools Suite

@RISK for Excel is a member of the DecisionTools Suite, a set of products for risk and decision analysis described in **Appendix D: Using @RISK With Other DecisionTools**. The default installation procedure of @RISK puts @RISK in a subdirectory of a main "DTOOLS" directory. This is quite similar to how Excel is often installed into a subdirectory of a "MSOFFICE" directory.

One subdirectory of the DTOOLS directory will be the @RISK directory (by default called RISK45). This directory contains the @RISK program files (RSKMODEL.EXE and RSKRSLTS.EXE) plus example models and other files necessary for @RISK to run. Another subdirectory of DTOOLS is the SYSTEM directory which contains files which are needed by every program in the DecisionTools Suite, including common help files and program libraries.

**The
DecisionTools
Toolbar**

When you launch one of the elements of the Suite (such as @RISK) from its desktop icon, Excel will load a "DecisionTools Suite" toolbar which contains one icon for each program of the Suite. This allows you to launch any of the other products in the suite directly from Excel.

Note: In order for TopRank, the what-if analysis program in the DecisionTools Suite, to work properly with @RISK, you must have release TopRank 1.5e or higher.

***Creating the
Shortcut in the
Windows
Taskbar***

Setting Up the @RISK Icons or Shortcuts

In Windows, setup automatically creates an @RISK command in the Programs menu of the Taskbar. However, if problems are encountered during Setup, or if you wish to do this manually another time, follow the following directions.

- 1) Click the Start button, and then point to Settings.*
- 2) Click Taskbar, and then click the Start Menu Programs tab.*
- 3) Click Add, and then click Browse.*
- 4) Locate the file RISK.EXE and double click it.*
- 5) Click Next, and then double-click the menu on which you want the program to appear.*
- 6) Type the name “ @RISK” , and then click Finish.*

Quick Start

On-line Tutorial

In the on-line tutorial, @RISK experts guide you through sample models in streaming .WMV movie format. This tutorial is a multi-media presentation on the main features of @RISK.

The system requirements for the tutorial are:

- Windows Media Player plug-in
- A computer with audio capability

The tutorial can be run by selecting the **Start Menu/ Programs/ Palisade DecisionTools/ Tutorials/ @RISK Tutorial** and clicking on the file **RISK45.html**.

Starting On Your Own

If you're in a hurry, or just want to explore @RISK on your own, here's a quick way to get started.

After attaching @RISK according to the Installation instructions outlined previously in this section:

- 1) *Click the @RISK icon in the Windows Start Programs Palisade DecisionTools group.*
- 2) *Use the Excel Open command to open the example spreadsheet FINANCE.XLS. The default location for the examples is C:\DTOOLS\RISK45\EXAMPLES.*
- 3) *Click the List icon on the @RISK Toolbar — the one on the Toolbar with the red and blue arrow. The Outputs and Inputs list, listing the distribution functions in the FINANCE worksheet along with your output cell C10, NPV at 10%, is displayed.*
- 4) *Click the "Simulate" icon — the one with the red distribution curve. You've just started a risk analysis on NPV for the FINANCE worksheet. The Simulation analysis is underway. When it is complete, your risk analysis results will be displayed.*

To make graphs for Risk Analysis results:

- 1) *When results are shown, right click on the name of an output or input in the Explorer list and select Histogram. A graph of simulation results for the highlighted output or input cell will be displayed.*
- 2) *To modify a graph, click the right mouse button when the cursor is located over the graph window. Select Graph Format from the pop-up menu.*

For all analyses, if you want to see @RISK "animate" its operation during the simulation, turn the Simulation Settings dialog box Update Display check box on or press the <Num Lock> key during the simulation. @RISK then will show you how it changes your spreadsheet iteration by iteration and generates results.

Quick Start with Your Own Spreadsheets

Working through the @RISK On-Line Tutorial and reading the @RISK Reference Guide is the best method for preparing to use @RISK on your own spreadsheets. However, if you're in a hurry, or just don't want to work through the Tutorial, here is a quick step-by-step guide to using @RISK with your own spreadsheets:

- 1) *Click the @RISK icon in the Windows Start Programs Palisade DecisionTools group.*
- 2) *If necessary, use the Excel Open command to open your spreadsheet*
- 3) *Examine your spreadsheet and locate those cells where uncertain assumptions or inputs are located. You will substitute @RISK distribution functions for these values.*
- 4) *Enter distribution functions for the uncertain inputs which reflect the range of possible values and their likelihood of occurrence. Start with the simple distribution types — such as UNIFORM, which just requires a minimum and maximum possible value, or TRIANG which just requires a minimum, most likely and maximum possible value.*
- 5) *Once you've entered your distributions, select the spreadsheet cell or cells for which you wish to get simulation results and click the "Add Output" icon — the one with the single red arrow — on the @RISK Toolbar.*

To run a simulation:

- 1) *Click the "Simulate" icon — the one with the red distribution curve — on the @RISK Toolbar. A simulation of your spreadsheet will be executed and results displayed.*

Using @RISK 4.5 Spreadsheets in @RISK 3.5 or earlier

@RISK 4.5 spreadsheets can only be used in @RISK 3.5 or earlier when the simple forms of distribution functions are used. In the simple distribution function format only required distribution parameters can be used. No new @RISK 4.5 distribution property functions can be added. In addition, RiskOutput functions must be removed and outputs reselected when simulating in @RISK 3.5.

Using @RISK 4.5 Spreadsheets in @RISK 4.0

@RISK 4.5 spreadsheets can be used directly in @RISK 4.0 with the following exceptions:

- **Alternate Parameter functions**, such as RiskNormalAlt, will not work and will return an error.
- **Cumulative Descending functions**, such as RiskCumulD, will not work and will return an error.

Chapter 2: An Overview to Risk Analysis

Introduction	17
What Is Risk?	19
Characteristics of Risk.....	19
The Need for Risk Analysis	20
Assessing and Quantifying Risk.....	21
Describing Risk with a Probability Distribution	22
What Is Risk Analysis?	23
Developing an @RISK Model.....	25
Variables.....	25
Output Variables.....	26
Analyzing a Model with Simulation.....	27
Simulation	27
How Simulation Works	28
The Alternative to Simulation	28
Making a Decision: Interpreting the Results.....	29
Interpreting a Traditional Analysis.....	29
Interpreting an @RISK Analysis	29
Individual Preference.....	30
The Distribution "Spread".....	30
Skewness	32
What Risk Analysis Can (Cannot) Do	33

Introduction

@RISK brings advanced modeling and Risk Analysis to Microsoft Excel. You might wonder if what you do qualifies as modeling and/or would be suitable for Risk Analysis. If you use data to solve problems, make forecasts, develop strategies, or make decisions, then you definitely should consider doing Risk Analysis.

Modeling is a catch-all phrase that usually means any type of activity where you are trying to create a representation of a real life situation so you can analyze it. Your representation, or model, can be used to examine the situation, and hopefully help you understand what the future might bring. If you've ever played "what-if" games with your project by changing the values of various entries, you are well on your way to understanding the importance of uncertainty in a modeling situation.

Okay, so you do analyses and make models — what is involved in making these analyses and models explicitly incorporate risk? The following discussion will try to answer this question. But don't worry, you don't have to be an expert in statistics or decision theory to analyze situations under risk, and you certainly don't have to be an expert to use @RISK. We can't teach you everything in a few pages, but we'll get you started. Once you begin using @RISK you'll automatically begin picking up the type of expertise that can't be learned from a book.

Another purpose of this chapter is to give you an overview of how @RISK works with your spreadsheet to perform analyses. You don't have to know how @RISK works to use it successfully, but you might find some explanations useful and interesting. This chapter discusses:

- *What risk is and how it can be quantitatively assessed.*
- *The nature of Risk Analysis and the techniques used in @RISK.*
- *Running a simulation.*
- *Interpreting @RISK results.*
- *What Risk Analysis can and cannot do.*

What Is Risk?

Everyone knows that "risk" affects the gambler about to roll the dice, the wildcatter about to drill an oil well, or the tightrope walker taking that first big step. But these simple illustrations aside, the concept of risk comes about due to our recognition of future uncertainty — our inability to know what the future will bring in response to a given action today. Risk implies that a given action has more than one possible outcome.

In this simple sense, every action is "risky", from crossing the street to building a dam. The term is usually reserved, however, for situations where the range of possible outcomes to a given action is in some way significant. Common actions like crossing the street usually aren't risky while building a dam can involve significant risk. Somewhere in between, actions pass from being nonrisky to risky. This distinction, although vague, is important — if you judge that a situation is risky, risk becomes one criterion for deciding what course of action you should pursue. At that point, some form of Risk Analysis becomes viable.

Characteristics of Risk

Risk derives from our inability to see into the future, and indicates a degree of uncertainty that is significant enough to make us notice it. This somewhat vague definition takes more shape by mentioning several important characteristics of risk.

First, risk can be either objective or subjective. Flipping a coin is an objective risk because the odds are well known. Even though the outcome is uncertain, an objective risk can be described precisely based on theory, experiment, or common sense. Everyone agrees with the description of an objective risk. Describing the odds for rain next Thursday is not so clear cut, and represents a subjective risk. Given the same information, theory, computers, etc., weatherman A may think the odds of rain are 30% while weatherman B may think the odds are 65%. Neither is wrong. Describing a subjective risk is open-ended in the sense that you could always refine your assessment with new information, further study, or by giving weight to the opinion of others. Most risks are subjective, and this has important implications for anyone analyzing risk or making decisions based on a Risk Analysis.

Second, deciding that something is risky requires personal judgment, even for objective risks. For example, imagine flipping a coin where you win \$1 for a heads and lose \$1 for a tails. The range between \$1 and -\$1 would not be overly significant to most people. If the stakes were \$100,000 and -\$100,000 respectively, most people would find the situation to be quite risky. There would be a wealthy few, however, who would not find this range of outcomes to be significant.

Third, risky actions and therefore risk are things that we often can choose or avoid. Individuals differ in the amount of risk they willingly accept. For example, two individuals of equal net worth may react quite differently to the \$100,000 coin flip bet described above — one may accept it while the other refuses it. Their personal preference for risk differs.

The Need for Risk Analysis

The first step in Risk Analysis and modeling is recognizing a need for it. Is there significant risk involved in the situation you are interested in? Here are a few examples that might help you evaluate your own situations for the presence of significant risk:

- **Risks for New Product Development and Marketing** — *Will the R&D department solve the technical problems involved? Will a competitor get to market first, or with a better product? Will government regulations and approvals delay product introduction? How much impact will the proposed advertising campaign have on sales levels? Will production costs be as forecast? Will the proposed sales price have to be changed to reflect unanticipated demand levels for the product?*
- **Risks for Securities Analysis and Asset Management** — *How will a tentative purchase affect portfolio value? Will a new management team affect market price? Will an acquired firm add earnings as forecast? How will a market correction impact a given industry sector?*
- **Risks for Operations Management and Planning** — *Will a given inventory level suffice for unpredictable demand levels? Will labor costs rise significantly with upcoming union contract negotiations? How will pending environmental legislation impact production costs? How will political and market events affect overseas suppliers in terms of exchange rates, trade barriers, and delivery schedules?*
- **Risks for Design and Construction of a Structure (building, bridge, dam,...)** — *Will the cost of construction materials and labor be as forecast? Will a labor strike affect the construction schedule? Will the levels of stress placed on the structure by peak load crowds and nature be as forecast? Will the structure ever be stressed to the point of failure?*

- **Risks for Investment in Exploration for Oil and Minerals** — *Will anything be found? If a deposit is found, will it be uneconomical, or a bonanza? Will the costs of developing the deposit be as forecast? Will some political event like an embargo, tax reform, or new environmental regulations drastically alter the economic viability of the project?*
- **Risks for Policy Planning** — *If the policy is subject to legislative approval, will it be approved? Will the level of compliance with any policy directives be complete or partial? Will the costs of implementation be as forecast? Will the level of benefits be what you projected?*

Assessing and Quantifying Risk

The first step in Risk Analysis and modeling is recognizing a need for it. Is there significant risk involved in the situation you are interested in? Here are a few examples that might help you evaluate your own situations for the presence of significant risk.

Realizing that you have a risky situation is only the first step. How do you quantify the risk you have identified for a given uncertain situation? "Quantifying risk" means determining all the possible values a risky variable could take and determining the relative likelihood of each value. Suppose your uncertain situation is the outcome from the flip of a coin. You could repeat the flip a large number of times until you had established the fact that half of the times it comes up tails and half of the times heads. Alternatively, you could mathematically calculate this result from a basic understanding of probability and statistics.

In most real life situations, you can't perform an "experiment" to calculate your risk the way you can for the flip of a coin. How could you calculate the probable learning curve associated with introducing new equipment? You may be able to reflect on past experiences, but once you have introduced the equipment, the uncertainty is gone. There is no mathematical formula that you can solve to get the risk associated with the possible outcomes. You have to estimate the risk using the best information you have available.

If you can calculate the risks of your situation the way you would for a coin flip, the risk is objective. This means that everyone would agree that you quantified the risk correctly. Most risk quantification, however, involves your best judgment.

There may not be complete information available about the situation, the situation may not be repeatable like a coin flip, or it just may be too complex to come up with an unequivocal answer. Such risk quantification is subjective, which means that someone might disagree with your evaluation.

Your subjective assessments of risk are likely to change when you get more information on the situation. If you have subjectively derived a risk assessment, you must always ask yourself whether additional information is available that would help you make a better assessment. If it is available, how hard and how expensive would it be to obtain? How much would it cause you to change the assessment you already have made? How much would these changes affect the final results of any model you are analyzing?

Describing Risk with a Probability Distribution

If you have quantified risk — determined outcomes and probabilities of occurrence — you can summarize this risk using a probability distribution. A probability distribution is a device for presenting the quantified risk for a variable. @RISK uses probability distributions to describe uncertain values in your Excel worksheets and to present results. There are many forms and types of probability distributions, each of which describes a range of possible values and their likelihood of occurrence. Most people have heard of a normal distribution — the traditional "bell curve". But there is a wide variety of distribution types ranging from uniform and triangular distributions to more complex forms such as gamma and weibull.

All distribution types use a set of arguments to specify a range of actual values and distribution of probabilities. The normal distribution, for example, uses a mean and standard deviation as its arguments. The mean defines the value around which the bell curve will be centered and the standard deviation defines the range of values around the mean. Over thirty types of distributions are available to you in @RISK for describing distributions for uncertain values in your Excel worksheets.

The @RISK Define Distribution window allows you to graphically preview distributions and assign them to uncertain values. Using its graphs, you can quickly see the range of possible values your distribution describes.

What Is Risk Analysis?

In a broad sense, Risk Analysis is any method — qualitative and/or quantitative — for assessing the impacts of risk on decision situations. Myriad techniques are used that blend both qualitative and quantitative techniques. The goal of any of these methods is to help the decision-maker choose a course of action, given a better understanding of the possible outcomes that could occur.

Risk Analysis in @RISK is a quantitative method that seeks to determine the outcomes of a decision situation as a probability distribution. In general, the techniques in an @RISK Risk Analysis encompass four steps:

- **Developing a Model** — *by defining your problem or situation in Excel worksheet format*
- **Identifying Uncertainty** — *in variables in your Excel worksheet and specifying their possible values with probability distributions, and identifying the uncertain worksheet results you want analyzed*
- **Analyzing the Model with Simulation** — *to determine the range and probabilities of all possible outcomes for the results of your worksheet*
- **Making a Decision** — *based on the results provided and personal preferences*

@RISK helps with the first three steps, by providing a powerful and flexible tool that works with Excel to facilitate model building and Risk Analysis. The results that @RISK generates can then be used by the decision-maker to help choose a course of action.

Fortunately, the techniques @RISK employs in a Risk Analysis are very intuitive. As a result, you won't have to accept our methodology on faith. And you won't have to shrug your shoulders and resort to calling @RISK a "black box" when your colleagues and superiors query you as to the nature of your Risk Analysis. The discussion to follow will give you a firm understanding of just what @RISK needs from you in the way of a model, and how an @RISK Risk Analysis proceeds.

Developing an @RISK Model

You are the "expert" at understanding the problems and situations that you would like to analyze. If you have a problem that is subject to risk, then @RISK and Excel can help you construct a complete and logical model.

A major strength of @RISK is that it allows you to work in a familiar and standard model building environment — Microsoft Excel. @RISK works with your Excel model, allowing you to conduct a Risk Analysis, but still preserves the familiar spreadsheet capabilities. You presumably know how to build spreadsheet models in Excel — @RISK now gives you the ability to easily modify these models for Risk Analysis.

Variables

Variables are the basic elements in your Excel worksheets that you have identified as being important ingredients to your analysis. If you are modeling a financial situation, your variables might be things like Sales, Costs, Revenues or Profits whereas if you are modeling a geologic situation, your variables might be things like Depth to Deposit, Thickness of Coal Seam or Porosity. Each situation has its own variables, identified by you. In a typical worksheet, a variable labels a worksheet row or column, for example:

Certain or Uncertain

You may know the values your variables will take in the time frame of your model — they are certain, or what statisticians call "deterministic". Conversely, you may not know the values they will take — they are uncertain, or "stochastic". If your variables are uncertain you will need to describe the nature of their uncertainty. This is done with probability distributions, which give both the range of values that the variable could take (minimum to maximum), and the likelihood of occurrence of each value within the range. In @RISK, uncertain variables and cell values are entered as probability distribution functions, for example:

RiskNormal(100,10)

RiskUniform(20,30)

RiskExpon(A1+A2)

RiskTriang(A3/2.01,A4,A5)

These "distribution" functions can be placed in your worksheet cells and formulas just like any other Excel function.

Independent or Dependent

In addition to being certain or uncertain, variables in a Risk Analysis model can be either "independent" or "dependent". An independent variable is totally unaffected by any other variable within your model. For example, if you had a financial model evaluating the profitability of an agricultural crop, you might include an uncertain variable called Amount of Rainfall. It is reasonable to assume that other variables in your model such as Crop Price and Fertilizer Cost would have no effect on the amount of rain — Amount of Rainfall is an independent variable.

A dependent variable, in contrast, is determined in full or in part by one or more other variables in your model. For example, a variable called Crop Yield in the above model should be expected to depend on the independent variable Amount of Rainfall. If there's too little or too much rain, then the crop yield is low. If there's an amount of rain that is about normal, then the crop yield would be anywhere from below average to well above average. Maybe there are other variables that affect Crop Yield such as Temperature, Loss to Insects, etc.

When identifying the uncertain values in your Excel worksheet, you have to decide whether your variables are correlated. These variables would all be "correlated" with each other. The Corrmatrix function in @RISK is used to identify correlated variables. It is extremely important to correctly recognize correlations between variables or your model might generate nonsensical results. For example, if you ignored the relationship between Amount of Rainfall and Crop Yield, @RISK might choose a low value for the rainfall at the same time it picked a high value for the crop yield — clearly something nature wouldn't allow.

Output Variables

Any model needs both input values and output results, and a Risk Analysis model is no different. An @RISK Risk Analysis generates results on cells in your Excel worksheet. Results are probability distributions of the possible values which could occur. These results are usually the same worksheet cells that give you the results of a regular Excel analysis — Profit, the "bottom line" or other such worksheet entries.

Analyzing a Model with Simulation

Once you have placed uncertain values in your worksheet cells and have identified the outputs of your analysis, you have an Excel worksheet that @RISK can analyze.

Simulation

@RISK uses simulation, sometimes called Monte Carlo simulation, to do a Risk Analysis. Simulation in this sense refers to a method whereby the distribution of possible outcomes is generated by letting a computer recalculate your worksheet over and over again, each time using different randomly selected sets of values for the probability distributions in your cell values and formulas. In effect, the computer is trying all valid combinations of the values of input variables to simulate all possible outcomes. This is just as if you ran hundreds or thousands of "what-if" analyses on your worksheet, all in one sitting.

What is meant by saying that simulation "tries all valid combinations of the values of input variables"? Suppose you have a model with only two input variables. If there is no uncertainty in these variables, you can identify a single possible value for each variable. These two single values can be combined by your worksheet formulas to calculate the results of interest — also a certain or deterministic value. For example, if the certain input variables are:

Revenues = 100
Costs = 90

then the result

Profits = 10

would be calculated by Excel from

Profits = 100 - 90

There is only one combination of the input variable values, because there is only one value possible for each variable.

Now consider a situation where there is uncertainty in both input variables. For example,

Revenues = 100 or 120
Costs = 90 or 80

gives two values for each input variable. In a simulation, @RISK would consider all possible combinations of these variable values to calculate possible values for the result, Profits.

There are four combinations:

Profits = Revenues - Costs

10 = 100 - 90

20 = 100 - 80

30 = 120 - 90

40 = 120 - 80

Profits also is an uncertain variable because it is calculated from uncertain variables.

How Simulation Works

In @RISK, simulation uses two distinct operations:

- *Selecting sets of values for the probability distribution functions contained in the cells and formulas of your worksheet*
- *Recalculating the Excel worksheet using the new values*

The selection of values from probability distributions is called sampling and each calculation of the worksheet is called an iteration.

The following diagrams show how each iteration uses a set of single values sampled from distribution functions to calculate single-valued results.

@RISK generates output distributions by consolidating single-valued results from all the iterations.

The Alternative to Simulation

There are two basic approaches to quantitative Risk Analysis. Both have the same goal — to derive a probability distribution that describes the possible outcomes of an uncertain situation — and both generate valid results. The first approach is the one just described for @RISK, namely, simulation. This approach relies on the ability of the computer to do a great deal of work very quickly — solving your worksheet repeatedly using a large number of possible combinations of input variable values.

The second approach to Risk Analysis is an analytical approach. Analytical methods require that the distributions for all uncertain variables in a model be described mathematically. Then the equations for these distributions are combined mathematically to derive another equation, which describes the distribution of possible outcomes. This approach is not practical for most uses and users. It is not a simple task to describe distributions as equations, and it is even more difficult to combine distributions analytically given even moderate complexity in your model. Furthermore, the mathematical skills necessary to implement the analytical techniques are significant.

Making a Decision: Interpreting the Results

@RISK analysis results are presented in the form of probability distributions. The decision-maker must interpret these probability distributions, and make a decision based on the interpretation. How do you interpret a probability distribution?

Interpreting a Traditional Analysis

Let's start by looking at how a decision-maker would interpret a single-valued result from a traditional analysis — an "expected" value. Most decision-makers compare the expected result to some standard or minimum acceptable value. If it's at least as good as the standard, they find the result acceptable. But, most decision-makers recognize that the expected result doesn't show the impacts of uncertainty. They have to somehow manipulate the expected result to make some allowance for risk. They might arbitrarily raise the minimum acceptable result, or they might non rigorously weigh the chances that the actual result could exceed or fall short of the expected result. At best, the analysis might be extended to include several other results — such as "worst case" and "best case" — in addition to the expected value. The decision-maker then decides if the expected and "best case" values are good enough to outweigh the "worst case" value.

Interpreting an @RISK Analysis

In an @RISK Risk Analysis, the output probability distributions give the decision-maker a complete picture of all the possible outcomes. This is a tremendous elaboration on the "worst-expected-best" case approach mentioned above. But the probability distribution does a lot more than just fill in the gaps between these three values:

- **Determines a "Correct" Range** — *Because you have more rigorously defined the uncertainty associated with every input variable, the possible range of outcomes may be quite different from a "worst case-best case" range — different, and more correct.*
- **Shows Probability of Occurrence** — *A probability distribution shows the relative likelihood of occurrence for each possible outcome.*

As a result, you no longer just compare desirable outcomes with undesirable outcomes. Instead, you can recognize that some outcomes are more likely to occur than others, and should be given more weight in your evaluation. This process also is a lot easier to understand than the traditional analysis because a probability distribution is a graph — you can see the probabilities and get a feel for the risks involved.

Individual Preference

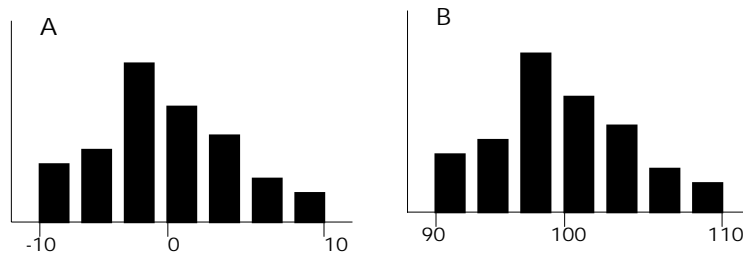
The results provided by an @RISK analysis must be interpreted by you as an individual. The same results given to different individuals may be interpreted differently, and lead to different courses of action. This is not a weakness in the technique, but a direct result of the fact that different individuals have different preferences with regard to possible choices, time, and risk. You might feel that the shape of the output distribution shows that the chances of an undesirable outcome far outweigh the chances of a desirable outcome. A colleague who is less risk averse might come to the opposite conclusion.

The Distribution "Spread"

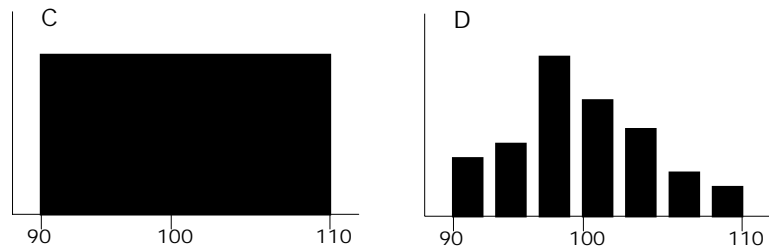
Range and likelihood of occurrence are directly related to the level of risk associated with a particular event. By looking at the spread and likelihood of possible results, you can make an informed decision based on the level of risk you are willing to take. Risk averse decision-makers prefer a small spread in possible results, with most of the probability associated with desirable results. But if you are a risk-taker, then you will accept a greater spread or possible variation in your outcome distribution. Furthermore, a risk-taker will be influenced by "bonanza" outcomes even if their likelihood of occurrence is small.

Regardless of your personal risk preferences, there are some general conclusions about riskiness that apply to all decision-makers. The following probability distributions illustrate these conclusions:

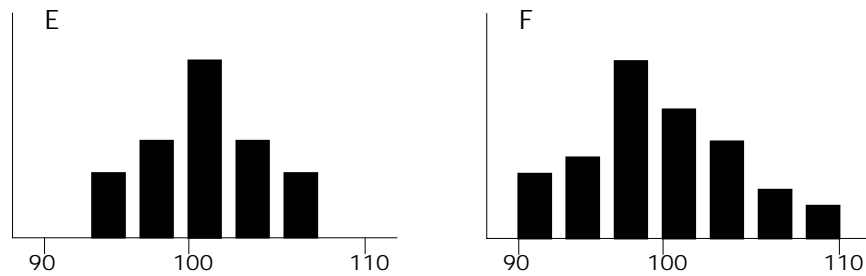
Probability distribution A represents greater risk than B despite identical shapes because the range of A includes less desirable results — the spread relative to the mean is greater in A than B.



Probability distribution C represents greater risk than D because the probability of occurrence is uniform across the range for C whereas it is concentrated around 98 for D.



Probability distribution F represents greater risk than E because the range is larger and the probability of occurrence is more spread out than for E.



Skewness

A simulation output distribution also can show skewness — how much the distribution of possible results deviates from being symmetrical. Suppose your distribution had a large positive 'tail'. If you saw only a single number for the expected result, you might not realize the possibility of a highly positive outcome that could occur in the tail. Skewness such as this can be very important to decision makers. By presenting all the information, @RISK "opens up" a decision by showing you all possible outcomes.

What Risk Analysis Can (Cannot) Do

Quantitative analysis techniques have gained a great deal of popularity with decision-makers and analysts in recent years. Unfortunately, many people have mistakenly assumed that these techniques are magic "black boxes" that unequivocally arrive at the correct answer or decision. No technique, including those used by @RISK, can make that claim. These techniques are tools that can be used to help make decisions and arrive at solutions. Like any tools, they can be used to good advantage by skilled practitioners, or they can be used to create havoc in the hands of the unskilled. In the context of Risk Analysis, quantitative tools should never be used as a replacement for personal judgment.

Finally, you should recognize that Risk Analysis cannot guarantee that the action you choose to follow — even if skillfully chosen to suit your personal preferences — is the best action viewed from the perspective of hindsight. Hindsight implies perfect information, which you never have at the time the decision is made. You can be guaranteed, however, that you have chosen the best personal strategy given the information that is available to you. That's not a bad guarantee!

Chapter 3: Upgrade Guide

Introduction	37
New @RISK Model Window	39
Defining Probability Distributions in your Spreadsheet.....	40
Review Distributions in the @RISK Model Window	41
Using Data to Define Probability Distributions	42
New @RISK Add-in Features	43
New Menus, Icons and Commands	43
New and Enhanced @RISK Functions in Excel	43
New @RISK Results Window	45
Other Enhancements	47
New Features in @RISK 4.5 vs @RISK 4.0.....	49
Advanced Analyses.....	50
Alternate Parameters for Probability Distributions	52
Cumulative Descending Percentiles.....	53
Quick Reports	54
Enhanced Define Distribution Window.....	55

Introduction

@RISK 4.5 and its predecessor, @RISK 4.0, are major upgrades to earlier versions of @RISK. @RISK 4.5 brings together features of its companion programs BestFit and RISKview to provide a fully functional risk analysis environment, while maintaining compatibility with earlier versions of @RISK. It also offers enhanced integration with Microsoft Excel to give easier access to simulation results directly in your spreadsheet. @RISK 4.5 is available in three versions – **Standard, Professional and Industrial** – to allow you to select the feature set you need.

Key Features

Key features of @RISK 4.5 include:

- Fully integrated **RISKview** (for distribution viewing) in all the versions.
- Fully integrated **BestFit** (for distribution fitting) in the **Professional and Industrial** versions.
- Fully integrated **RISKOptimizer** (for Simulation Optimization) in the **Industrial** version.

<p><i>Note: RISKview, BestFit and RISKOptimizer are also available as stand-alone programs.</i></p>
--

- **New toolbars, graphs and “Explorer” interface**
- **Improved integration with Excel with new functions and new reporting in Excel**
- **Improved performance with faster loading and simulation**
- **Full compatibility with existing @RISK models and functions**

Key enhancements of @RISK 4.5 vs. @RISK 4.0 include:

- Three new analyses – **Goal Seek, Stress Analysis and Advanced Sensitivity Analysis** – for advanced investigations on @RISK models (Professional and Industrial versions only)
- **Alternate parameters (such as percentiles)** can be used for defining many distribution types, and the distribution functions in Excel have been added that support alternate parameters
- **Quick reports**, designed for printing, for quick, single page reports on simulation results

- **Integrated support for multiple CPUs** in a single PC for high-speed simulations through parallel processing (Industrial version only)
- **Enhanced Define Distribution window**, including pop-up distribution palette, intelligent default parameters, easy entry of Excel cell references and more
- **Other enhancements**, including improved filtering, report formatting and more

Note: The information provided in this chapter is designed for users familiar with earlier versions of @RISK. New users should skip this chapter and continue with Chapter 4: Getting to Know @RISK to gain a full understanding of the operation and features of @RISK 4.5.

Three Main Components of @RISK 4.5

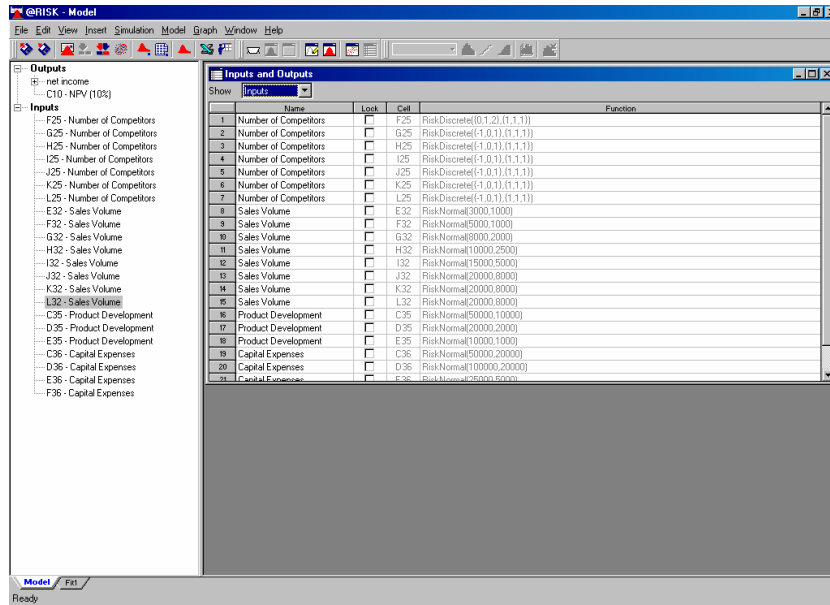
@RISK 4.5 is comprised of three main components:

- 1) **@RISK Model** window for listing inputs and outputs, viewing input distributions, fitting distributions, and defining correlations. @RISK Model also allows the pop-up graphical definition of distributions for components of cell formulas.
- 2) **@RISK add-in to Excel**, including new menus and icons, new distribution functions, new statistics functions, new output functions, and new simulation reports in Excel.
- 3) **@RISK Results** window for interactive graphs of simulation results, statistics, data, sensitivity and scenario reports.

Each of the three components share a common user interface including an “Explorer-style” listing of simulation inputs and outputs and customizable toolbars and icons.

New @RISK Model Window

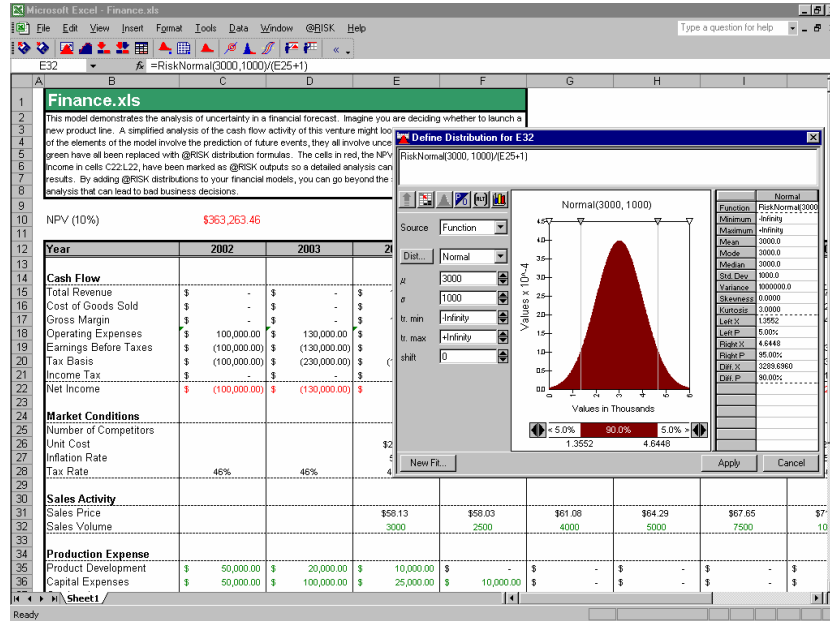
A new @RISK Model Window provides an entire set of options for assigning and viewing probability distributions used in your spreadsheet model, correlating them, and fitting distributions to data. This window allows you to handle all the tasks necessary for setting up your @RISK model prior to simulating it.



Defining Probability Distributions in your Spreadsheet

With @RISK 4.5 you can easily assign probability distributions to uncertain values in your spreadsheet model using a “pop-up” window. This capability will be familiar to users of Palisade’s RISKview program.

Pop-Up Window for Assigning Distributions



Using this pop-up, you can:

- **Preview and assign probabilities to values in Excel cells and formulas.** This allows the quick, graphical assignment of distributions to any number or entry in an Excel cell formula, plus editing of previously entered distribution functions.
- **Automatically enter distribution functions to formulas.** All edits made via RISKview pop-up are added directly to the cell formula in Excel.
- **Fit probability distributions to data in Excel** and use the results of the fit as a probability distribution in a formula.
- **The pop-up window also allows you to edit multiple distributions in a single cell.**

Graphical Assessment of Probabilities

With @RISK 4.5's pop-up Define Distribution window, you can interactively switch between available probability distributions and preview the probabilities they describe. While previewing distributions, you can:

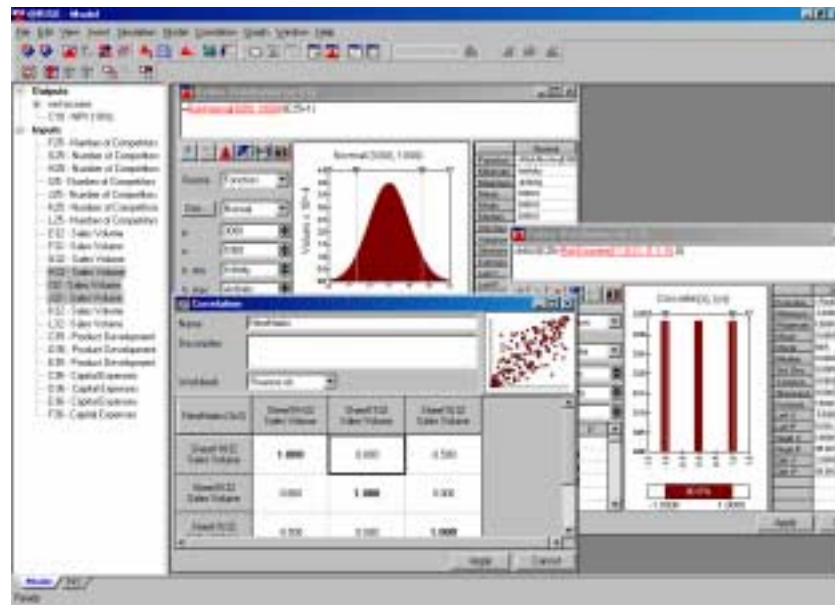
- **Interactively set and compare probabilities using sliding delimiters.**
- **Overlay multiple distributions to make comparisons.**
- **Change graph type and scaling using toolbars and the mouse.**

Review Distributions in the @RISK Model Window

The @RISK Model window provides a complete “Explorer-style” list of all input probability distributions and simulation outputs described in your model. This replaces the Outputs and Inputs list found in @RISK version 3.5 and earlier. From this list, you can:

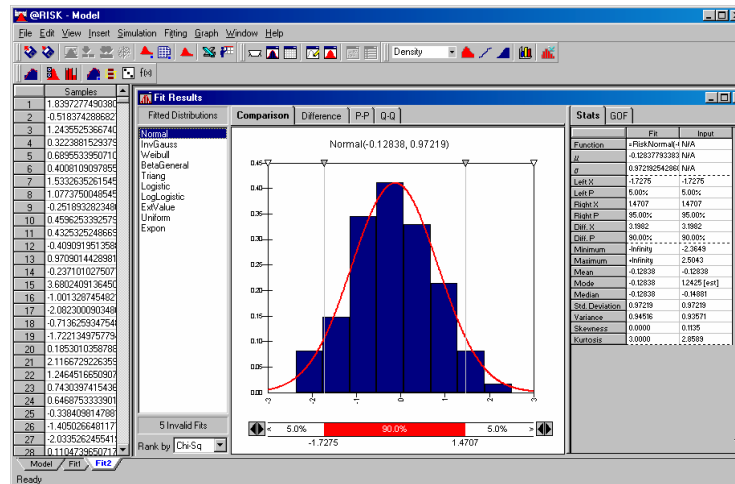
- **Edit any input distribution or output by simply clicking on output or input in Explorer.**
- **Quickly graph and display all defined inputs.**
- **Edit and preview correlation matrices.**

Correlation Matrix and Distribution Graphs in the Model Window



Using Data to Define Probability Distributions

The @RISK Model window fully integrates a new and enhanced version of Palisade's BestFit program to allow you to fit probability distributions to your data (Professional and Industrial versions only). The distributions which result from a fit are then automatically added to the input distribution list in the @RISK Model window and added to your spreadsheet model.



The distribution fitting features of the @RISK Model window include:

Distribution Fitting in @RISK Model Window

- **The fitting of sample data (continuous or discrete) and data from a density or cumulative curve.**
- **Convenient result display that shows all relevant information about a single fit.**
- **Ranking of fits based on Chi-Squared, Kolmogorov-Smirnov, or Anderson-Darling statistics.**
- **Comparison graphs, difference graphs and P-P and Q-Q plots.**
- **Statistics and Goodness-of-fit tests.**
- **A summary window with results of all fits in a single report.**
- **Advanced fitting control, including the ability to control exactly how the Chi-Squared statistic is calculated using equal interval binning, equal probability binning or custom binning.**
- **Ability to define a custom list of predefined distributions for fitting.**
- **Ability to define multiple fits in a single project using a tabbed format similar to Microsoft Excel.**

New @RISK Add-in Features

@RISK 4.5 includes a variety of new functions, menus and commands that make it easy to define your simulation model directly in your spreadsheet. This new functionality is provided in a new add-in program **RISK.XLA** that is installed with @RISK.

New Menus, Icons and Commands

The @RISK 4.5 add-in program in Excel includes the following new menus and commands:

- An **@RISK menu** is added to the Excel menubar. This contains all commands necessary for setting up and running a simulation of your spreadsheet model.
- An **@RISK “pop-up” menu** is displayed on a right mouse click on a spreadsheet cell. This menu allows you to define probability distributions for values in a cell formula and define simulation outputs.
- **Reports icon** for selecting reports on simulation results to be generated in Excel.

New and Enhanced @RISK Functions in Excel

@RISK 4.5 includes both new and enhanced custom functions that can be included in Excel cells and formulas. These functions include the RiskOutput function, @RISK statistics functions, enhanced @RISK distribution functions and @RISK reporting functions.

RiskOutput Functions

Output cells are defined using new RiskOutput functions. These functions allow easy copying, pasting and moving of output cells. RiskOutput functions are automatically added when the standard @RISK Add Output icon is pressed. RiskOutput functions optionally allow you to name your simulation outputs and add individual output cells to output ranges. A typical RiskOutput function might be:

=RiskOutput(“Profit”)+NPV(.1,H1...H10)

where the cell, prior to its selection as a simulation output, simply contained the formula

= NPV(.1,H1...H10)

The added RiskOutput function here selects the cell as a simulation output and gives the output the name “Profit”.

Statistics Functions

New @RISK statistics functions return a desired statistic on simulation results. For example, the function *RiskMean(A10)* returns the mean of the simulated distribution for the cell A10. These functions are updated real-time as a simulation is running.

@RISK statistics functions include all standard statistics plus percentiles and targets (for example, *=RiskPercentile(A10,.99)* returns the 99th percentile of the simulated distribution). @RISK statistics functions can include cell references for arguments just as standard Excel functions.

Graphing Function

A special @RISK function *RiskResultsGraph* will automatically place a graph of simulation results wherever it is used in a spreadsheet. For example, *=RiskResultsGraph (A10)* would place a graph of the simulated distribution for A10 directly in your spreadsheet at the function's location at the end of a simulation. Additional optional arguments to *RiskResultsGraph* allow you to select the type of graph you want to create, its format, scaling and other options.

Enhanced Distribution Functions

Additional options for @RISK probability distribution functions can be used to name input probability distributions, truncate their sampling, correlate them, and temporarily block sampling. These options are invoked through additional optional arguments to distribution functions. For example, the distribution function:

=RiskNormal(10,5,"Price",RiskTruncate(0,15))

would specify a normal distribution named *Price* with a mean of 10, a standard deviation of 5, a minimum possible value of 0, and a maximum of 15.

All new arguments to @RISK probability distribution functions are optional as all functions can be used as they were in earlier versions of @RISK.

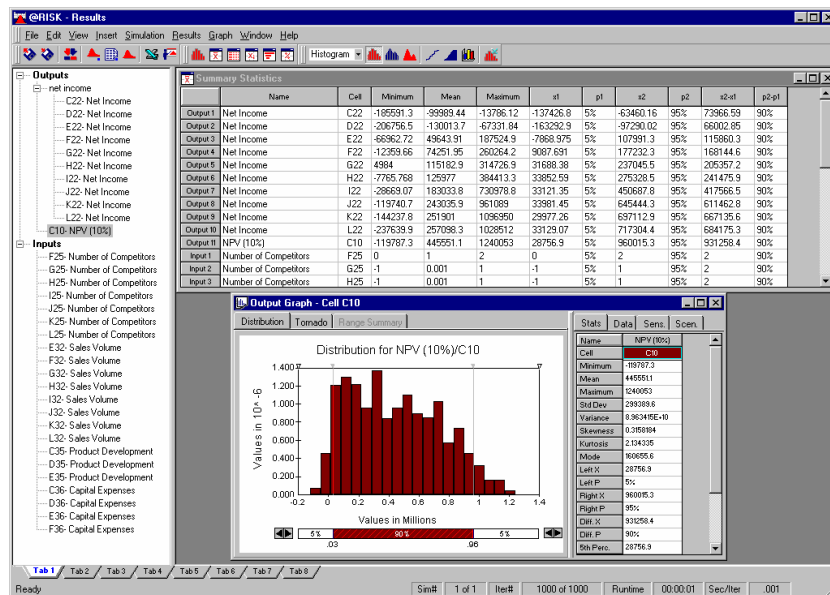
Reporting in Excel

Any standard simulation report can be placed directly in Excel at the end of a simulation. You can select to place pre-formatted simulation reports and graphs directly in Excel, without going through the @RISK Results program. You can also create custom templates which allow you to generate a standard report in Excel after each simulation.

Note: In @RISK 4.5, a simulation model is defined by the @RISK entries in cell formulas (distribution functions, outputs) and can run entirely within Excel, without accessing @RISK Model for model definition or @RISK Results for viewing results.

New @RISK Results Window

The @RISK Results window familiar to users of earlier versions of @RISK has been enhanced to provide more interactive reporting and graphing of simulation results.



New Results Window Options

New features in the @RISK Results window include:

- **“Explorer” style list of outputs and inputs** for which simulation results were collected.
- **Graphing of simulated distributions by simply clicking on output or input in Explorer.**
- **Graphs include tabbed reports** on statistics, data, sensitivities, and scenarios for graphed results, and any overlays.
- **Most graph changes can be made using toolbars and mouse,** including rescaling by dragging axes and setting the graph type using toolbar icons.
- **Probabilities can be set and compared using sliding delimiters.**
- **Full report windows each provide a standard @RISK report** (statistics, data, sensitivities, scenarios).
- **The placement of related reports and graphs on separate tabs.**

Reports in Results Window and Excel

Reporting in @RISK 4.5 is not only available in the @RISK Results window. In addition to the interactive graphs and reports of simulation results available in the @RISK Results window, you can use statistics and graphing functions and add-in reports to place your simulation results directly in Excel.

Microsoft Excel - Book7

@RISK Summary Report

General Information

Workbook Name	Finance.xls
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	22
Number of Outputs	11
Sampling Type	Latin Hypercube
Simulation Start Time	10/20/01 13:19:04
Simulation Stop Time	10/20/01 13:19:05
Simulation Duration	0.00.01
Random Seed	1736530771

Output and Input Summary Statistics

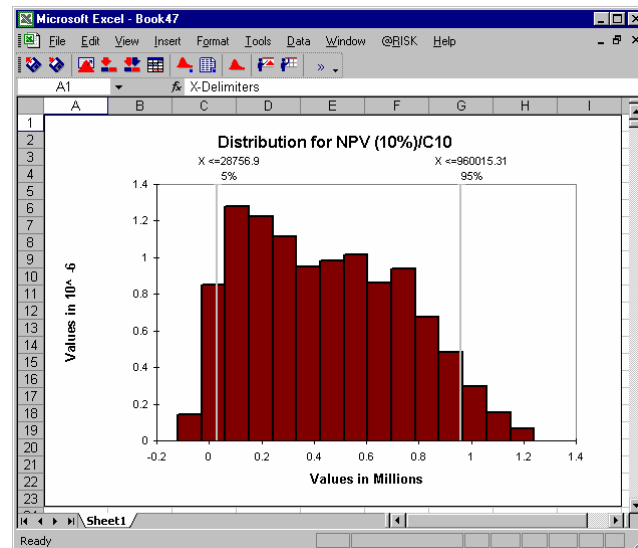
Output Name	Output Cell	Simulation	Minimum	Maximum	Mean	Std Dev	x1	p1
Net Income	\$C\$22	Finance.xls	\$ (195,591.30)	\$ (13,786.12)	\$ (99,989.43)	\$ 22,448.84	\$ (137,426.75)	
Net Income	\$D\$22	Finance.xls	\$ (206,756.53)	\$ (67,331.84)	\$ (130,013.71)	\$ 20,122.94	\$ (163,292.88)	
Net Income	\$E\$22	Finance.xls	\$ (66,962.72)	\$ 187,524.92	\$ 49,643.91	\$ 35,344.04	\$ (7,868.98)	
Net Income	\$F\$22	Finance.xls	\$ (12,369.66)	\$ 260,264.20	\$ 74,251.95	\$ 57,958.84	\$ 9,087.69	
Net Income	\$G\$22	Finance.xls	\$ 4,984.00	\$ 314,726.91	\$ 115,182.90	\$ 63,988.77	\$ 31,688.38	
Net Income	\$H\$22	Finance.xls	\$ (7,765.77)	\$ 384,413.28	\$ 125,876.99	\$ 77,818.05	\$ 33,852.59	
Net Income	\$I\$22	Finance.xls	\$ (29,869.07)	\$ 730,978.81	\$ 183,033.74	\$ 139,464.13	\$ 33,121.35	
Net Income	\$J\$22	Finance.xls	\$ (119,740.72)	\$ 961,089.00	\$ 243,036.89	\$ 197,074.33	\$ 33,981.45	
Net Income	\$K\$22	Finance.xls	\$ (144,237.78)	\$ 1,096,960.38	\$ 251,901.00	\$ 213,374.06	\$ 29,977.26	
Net Income	\$L\$22	Finance.xls	\$ (237,639.86)	\$ 1,028,512.13	\$ 257,098.27	\$ 220,219.20	\$ 33,129.07	
NPV (10%)	\$C\$10	Finance.xls	\$ (\$119,787.33)	\$ 1,240,053.13	\$ 445,551.11	\$ 299,389.64	\$ 28,756.90	

Input Name	Input Cell	Simulation	Minimum	Maximum	Mean	Std Dev	x1	p1
Number of Competitors	\$F\$25	Finance.xls	0	2	1	0.816496681	0	
Number of Competitors	\$G\$25	Finance.xls	-1	1	0.001	0.817108774	-1	

Summary Report / Summary Quick Report / Net Income C22 / Net Income D22 / Net Income E22

Graphs in Excel Format

All @RISK graphs may be created as standard Excel format graphs to allow easy editing and customization in your spreadsheet. All standard Excel editing options are available for these improved @RISK 4.5 Excel format graphs.



Other Enhancements

@RISK 4.5 includes other enhancements to improve the usability of simulations and spreadsheet models created with @RISK, including:

- **Real time updating of simulation results**
- **A single results datafile with the .RSK extension to ease the transfer of simulation models among users.**
- **All simulation settings (outputs, # of iterations, etc.) stored in the workbook being simulated so a model may be used and simulated without a saved .RSK file**
- **Command/Icon in Excel to select all cells containing @RISK distribution functions or outputs**

New Features in @RISK 4.5 vs @RISK 4.0

@RISK 4.5 brings a set of new analyses and new options to allow easier modeling and more in-depth studies on @RISK 4.0 models. New enhancements include:

- **Three New Advanced Analyses - Advanced Sensitivity Analysis, Stress Analysis, and Goal Seek** (@RISK Professional and Industrial only)
- **Alternate Parameters for Probability Distributions**, allowing the entry of percentile parameters as arguments to many input probability distributions. These alternate parameters are available in both the pop-up Define Distribution window or in distribution functions in Excel.
- **Cumulative Descending Percentiles**, where percentile probabilities can be optionally reported as cumulative descending values as well as cumulative ascending values. Alternate percentile parameters for probability distributions can also be entered as cumulative descending percentiles.
- **Quick Reports** - single one page reports in Excel containing statistics and graphs for a simulation result, formatted for printing.
- **Enhanced Define Distribution window**, with point and click selection of references from Excel, a pop-up distribution palette for selecting distributions, a new right-click menu and other enhancements.
- **Improved Error Reporting** during simulation, where the **Pause On Error** option now identifies the output(s) with errors and the cells in your model that caused the error for each.

The RISK45 directory on your system contains **multi-media tutorials** that illustrate the new capabilities of @RISK 4.5. These tutorials require a media player capable of running .WMV files and a PC with audio.

Advanced Analyses

The Advanced Analyses include **Advanced Sensitivity Analysis**, **Stress Analysis**, and **Goal Seek**. Each of these uses @RISK's multiple simulation capability to analyze a simulation model.

- **Goal Seek** allows you to find a specific simulated statistic for a cell (for example, the mean or standard deviation) by adjusting the value of another cell.
- **Stress Analysis** allows you to analyze the effects of stressing @RISK distributions. Stressing a distribution restricts samples drawn from the distribution to values between a specified pair of percentiles or samples a new “stress” distribution instead of the original distribution in your model.
- **Advanced Sensitivity Analysis** allows you to determine the effects of inputs on @RISK outputs. An input can be either an @RISK distribution or a cell in your Excel workbook. Advanced Sensitivity Analysis runs a full simulation at each of a set of possible values for an input, tracking the simulation results at each value.

Each of these analyses has its own dialogs and generates a set of pre-formatted reports and graphs in Excel.

Advanced Sensitivity Analysis Summary

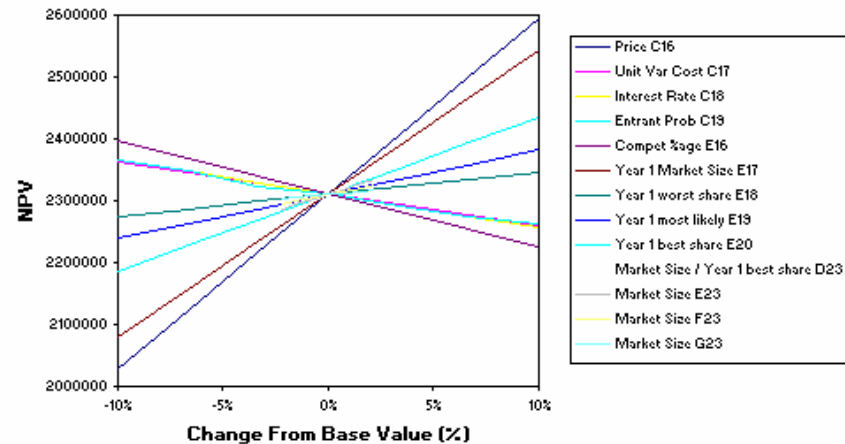
This report summarizes changes to the simulated distribution for NPV caused by stepping through 14 inputs. Each input is stepped through several values, and a full simulation was run at each value. A total of 98 simulations were completed

Summary Information

Output Name	NPV
Output Reference	C32

Inputs Ranked by Mean				Output			
Name	Book	Analysis	Value	Mean	Min	Max	StdDev
Price	Hippo.xls	Base +10.00%	2.4200000052	\$2,532,863	\$306,529	\$4,677,799	\$702,095
Year 1 Market Si	Hippo.xls	Base +10.00%	1100000	\$2,541,539	\$890,538	\$4,585,169	\$688,192
Price	Hippo.xls	Base +6.67%	2.3466666725	\$2,438,752	\$875,546	\$4,507,978	\$676,606
Year 1 Market Si	Hippo.xls	Base +6.67%	1066666.67	\$2,464,522	\$863,552	\$4,446,225	\$667,337
Year 1 best share	Hippo.xls	Base +10.00%	0.7699999987	\$2,434,887	\$810,881	\$4,524,860	\$704,663
Price	Hippo.xls	Base +3.33%	2.2733333397	\$2,404,621	\$842,563	\$4,338,157	\$651,117
Compet %age	Hippo.xls	Base -10.00%	0.1800000003	\$2,396,230	\$880,733	\$4,201,606	\$630,811
Year 1 best share	Hippo.xls	Base +6.67%	0.7466666656	\$2,393,418	\$810,457	\$4,405,891	\$678,034
Year 1 Market Si	Hippo.xls	Base +3.33%	1033333.34	\$2,387,506	\$836,566	\$4,307,280	\$646,483
Year 1 most likel	Hippo.xls	Base +10.00%	0.4400000007	\$2,381,934	\$811,414	\$4,216,301	\$628,490

Mean of NPV C32 vs Percentage Change of Inputs



Alternate Parameters for Probability Distributions

@RISK 4.5 allows the entry of percentile parameters as arguments to many input probability distributions. This allows you to specify values for specific percentile locations of an input distribution as opposed to the traditional arguments used by the distribution. For example, the distribution:

RiskNormal(100,20) – specifying a normal distribution with a mean of 100 and a standard deviation of 20

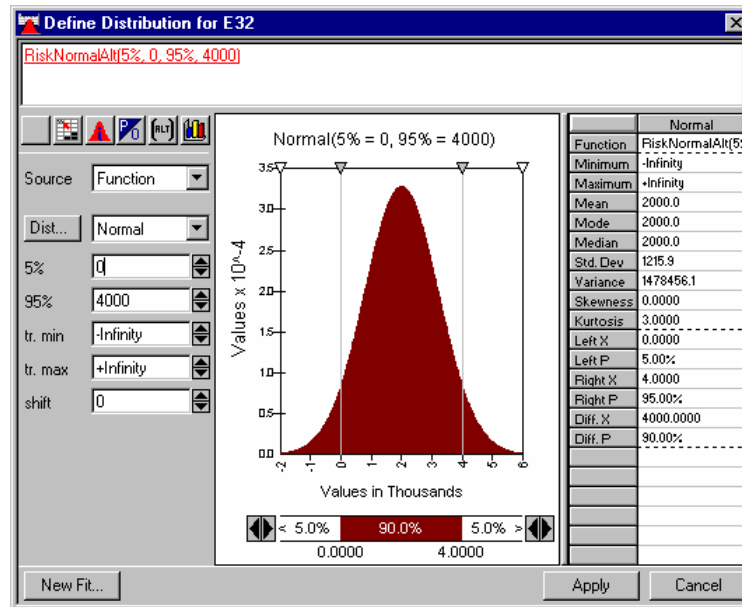
could also be entered as:

RiskNormalAlt(5%, 67.10, 95%, 132.89) - specifying a normal distribution with the 5th percentile at the value of 67.10 and the 95th percentile at the value of 132.89.

Percentiles may also be mixed with the standard distribution arguments, such as:

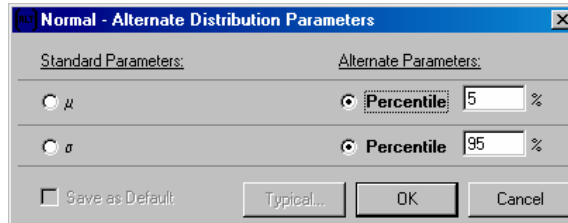
RiskNormalAlt("mu", 100, 95%, 132.89) - specifying a normal distribution with a mean of 100 and the 95th percentile at the value of 132.89.

These alternate parameter functions may be entered directly in your spreadsheet as with other @RISK distribution functions, or in the Define Distribution window:



The ALT icon

Clicking the ALT icon allows you to switch from standard distribution arguments to alternate percentile arguments:



Sampling Distributions with Alternate Parameters

A set of percentile arguments may be set as the default for a given distribution type, so that every lognormal distribution, for example, will be entered using a 10th and 90th percentile value.

During a simulation @RISK calculates the appropriate distribution whose percentile values equal those alternate parameter values entered and then samples that distribution. Just like all @RISK functions, the entered arguments may be references to other cells or formulas, and argument values may change iteration to iteration during a simulation.

For more information on the @RISK distributions that are available using alternate parameters, see the **Reference: @RISK Functions** chapter of this manual, or check the list shown when the class of functions titled **@RISK Distrib (Alt Params)** is shown in the Function Wizard in Excel.

Cumulative Descending Percentiles

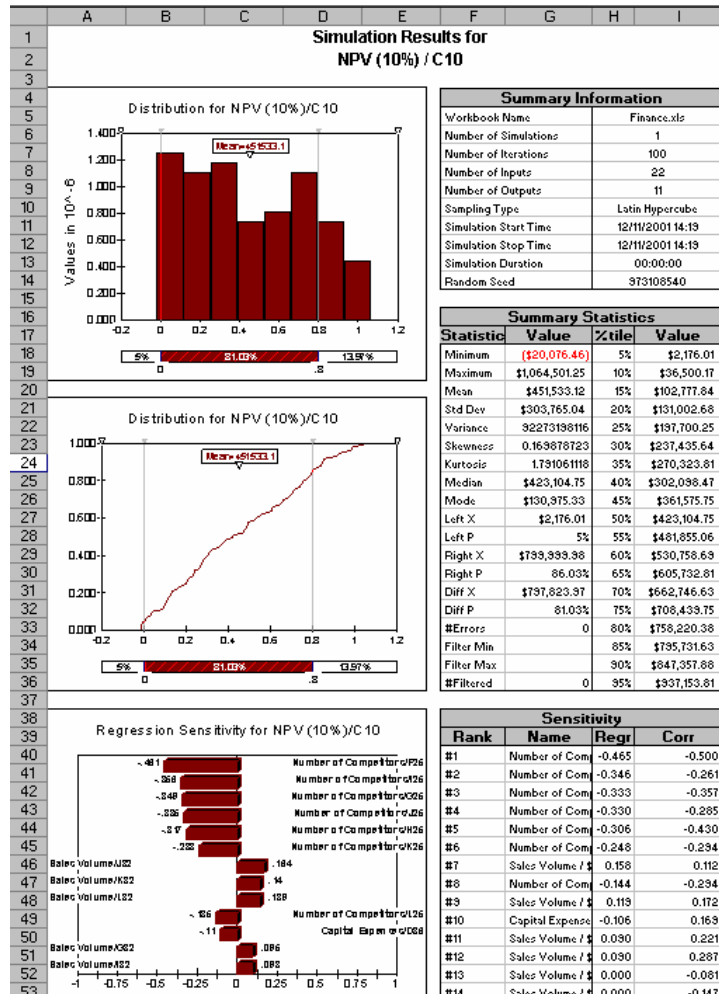
@RISK 4.5 can report percentile probabilities as cumulative descending values as well as cumulative ascending values. This option causes reports to display percentiles as the probability of obtaining a value above a given threshold. The display of cumulative descending percentiles is selected on the @RISK add-in menu **Options** command.

Cumulative descending percentiles may also be used in specifying alternate percentile parameters for probability distributions. In addition, arguments to the RiskCumul probability distribution may be entered using descending probabilities. A new set of @RISK functions allow the entry of these cumulative descending values. Each of these functions has a "D" after the function name, such as **RiskCumulD**, **RiskNormalAltD**, etc. For more information on using these functions, see the **Reference: @RISK Functions** chapter of this manual.

Quick Reports

Quick Reports are single one page reports in Excel containing statistics and graphs for a simulation result.

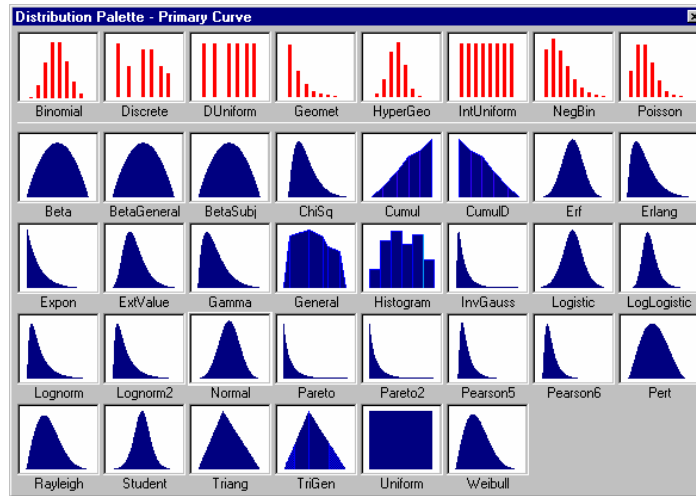
Quick reports can be generated by simply right clicking on a graph in the @RISK Results Window and selecting **Quick Report**, or through the **@RISK Report Settings** dialog. Using the Settings dialog, you may also choose to automatically generate Quick Reports for each output in your model at the end of a simulation.



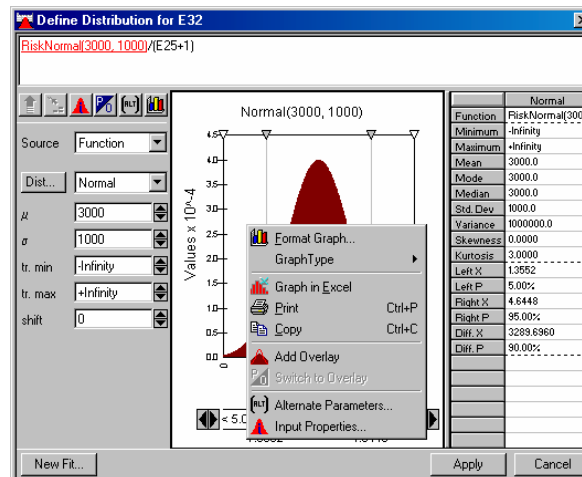
Enhanced Define Distribution Window

The pop-up Define Distribution window includes several new enhancements designed to make the graphical definition of probability distributions easier. These include:

- A new **Enter Excel Reference** icon allows the point and click selection of cell references for distribution arguments
- A pop-up **distribution palette** (displayed when the **Dist..** button is clicked) makes the selection of a distribution type easier

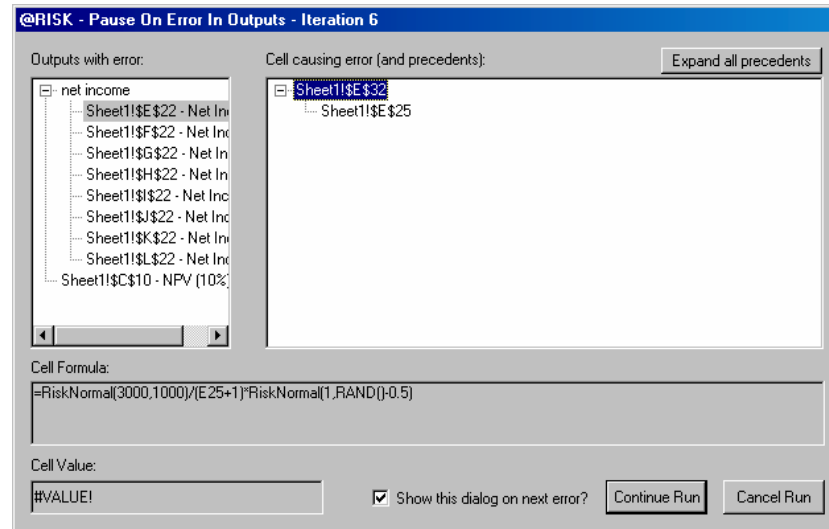


- A new **right-click menu** for easy selection of Define Distribution window options



Improved Error Reporting

The **Pause on Error in Outputs** option in the Simulation Settings dialog now provides a detailed listing of the outputs for which errors were generated during a simulation and the cells in your spreadsheet that caused the error.



When an error is generated for a simulation output in an iteration of a simulation, the Pause on Error in Outputs dialog shows each output for which an error was generated and the cell whose formula caused the output's error value. You can also review the formulas and values for cells which are precedents to the "error causing" cell, in order to examine values which feed into the problem formula.

Chapter 4: Getting to Know @RISK

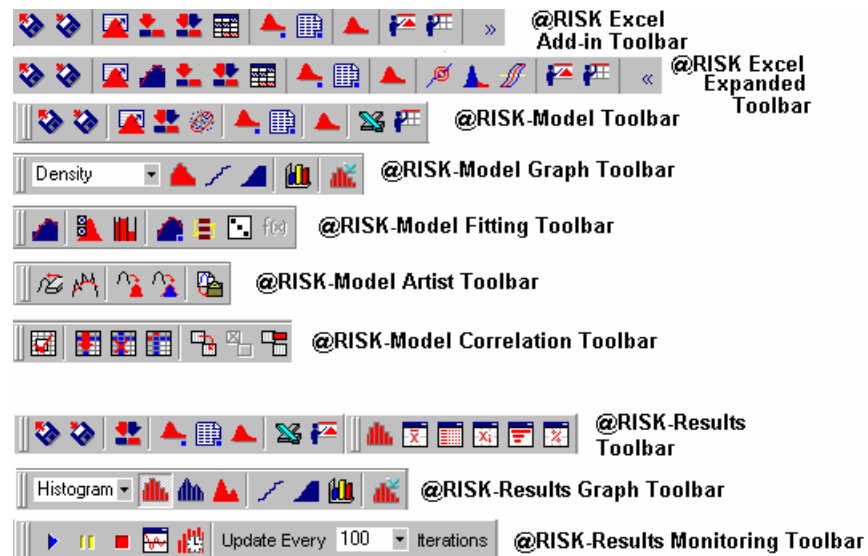
A Quick Overview to @RISK.....	59
How Does Risk Analysis Work?	60
Distribution Functions.....	60
Simulation Outputs	62
Listing all Outputs and Distribution Functions.....	62
Using Data to Define Probability Distributions	63
Running a Simulation	63
Simulation Results.....	64
Advanced Analytical Capabilities	66
Setting Up and Simulating an @RISK Model	69
Probability Distributions in Your Worksheet	69
Fitting Distributions To Data	71
Fitting Data to Define a Distribution.....	73
Correlating Input Variables	75
Simulation Settings	76
Running a Simulation	78
Simulation Status.....	80
Results Window	81
Graphing Results	84
Sensitivity Analysis Results	87
Scenario Analysis Results	88
Reporting in Excel.....	90
Quick Start.....	11
Quick Start with Your Own Spreadsheets	12
Using @RISK 4.5 Spreadsheets in Earlier Versions of @RISK	13

A Quick Overview to @RISK

@RISK extends the analytical capabilities of Microsoft Excel to include risk analysis and simulation. These techniques allow you to analyze your spreadsheets for risk. Risk Analysis identifies the range of possible outcomes you can expect for a spreadsheet result and their relative likelihood of occurrence.

To add risk analysis capabilities to your spreadsheet @RISK uses 1) **menus, Toolbar and custom functions in your spreadsheet**, 2) a **Model window** for defining model inputs and 3) a **Results window** for reviewing simulation results.

@RISK Toolbars



The Toolbars are used to make selections from @RISK or your spreadsheet in "add-in" style. In addition, the DecisionTools toolbar is used to access the other programs in the DecisionTools Suite. See **Appendix B: Using @RISK with Other DecisionTools** for more information on the Suite.

Note: The @RISK add-in in Excel has two available toolbars – the **standard** toolbar and an **expanded** version that contains tools for the Advanced Analyses available in @RISK Professional and Industrial. Clicking the "expansion" icon at the end of the toolbar changes the toolbar from standard to expanded and back.

Using the On-line Tutorial

The material in this chapter is presented on-line in the @RISK tutorial. This can be run by selecting the **Start Menu/ Programs/ Palisade**

How Does Risk Analysis Work?

@RISK uses the technique of Monte Carlo simulation for risk analysis. With this technique, uncertain input values in your spreadsheet are specified as probability distributions. An input value is a value in a spreadsheet cell or formula which is used to generate results in your spreadsheet. In @RISK, a probability distribution which describes the range of possible values for the input is substituted for its original single fixed value. To find out more about inputs and probability distributions, see **Chapter 2** of this User's Guide, **An Overview to Risk Analysis**.

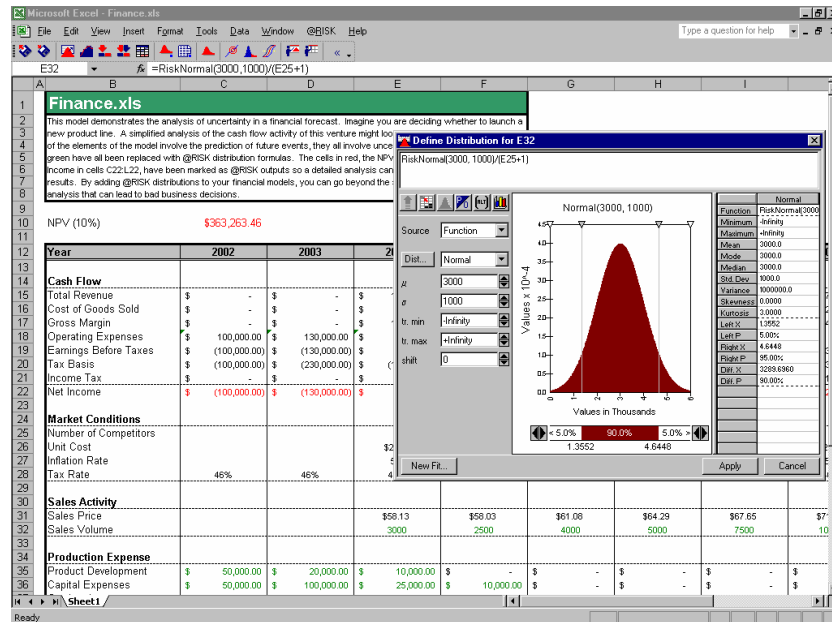
Distribution Functions

In @RISK, probability distributions are entered directly into your worksheet formulas using custom distribution functions. These new functions, each of which represents a type of probability distribution (such as NORMAL or BETA), are added to your spreadsheets' functions set by @RISK. When entering a distribution function you enter both the function name, such as **RiskTriang** — a triangular distribution — and the arguments which describe the shape and range of the distribution, such as **RiskTriang** (10,20,30), where 10 is the minimum value, 20 the most likely value and 30 the maximum value.

Distribution functions may be used anywhere in your spreadsheet that there is uncertainty about the value which is used. @RISK's functions may be used just as you would use any normal spreadsheet functions — include them in mathematical expressions and have cell references or formulas as arguments.

Define Distribution Window

@RISK includes a pop-up Define Distribution window that allows you to easily add probability distribution functions to spreadsheet formulas. By right-clicking on a cell in your spreadsheet (or by clicking the Define Distribution icon) you can display this window.



The @RISK Define Distribution window graphically displays probability distributions which can be substituted for values in a spreadsheet formula. By changing the displayed distribution you can see how various distributions would describe the range of possible values for an uncertain input in your model. The displayed statistics further show how a distribution defines an uncertain input.

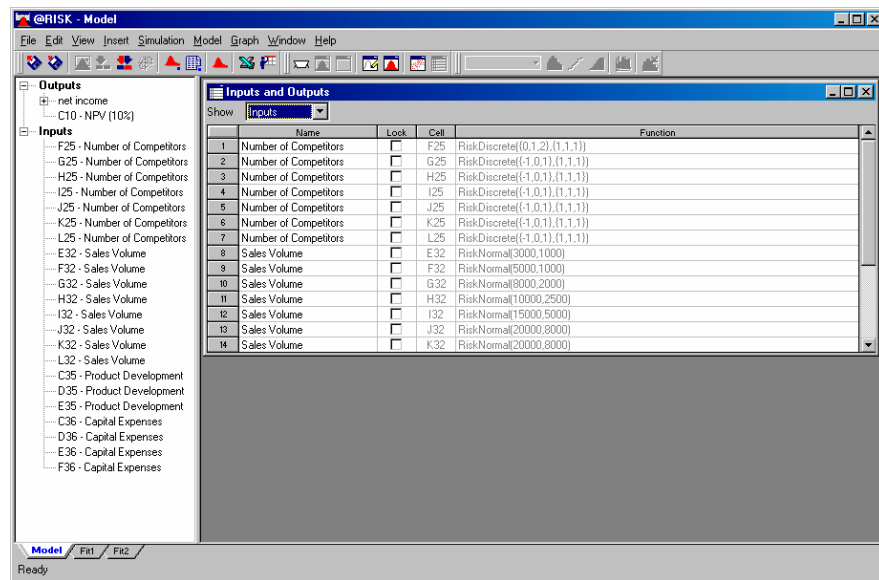
The graphical display of an uncertain input is useful in showing your definition of an uncertain input to others. It clearly displays the range of possible values for an input and the relative probability of any value in the range occurring. Working with distribution graphs you can easily incorporate assessments of uncertainty from experts into your risk analysis models.

Simulation Outputs

Once distribution functions have been entered into your spreadsheet, you need to identify those cells (or ranges of cells) that you are interested in seeing simulation results for. Typically, these output cells contain the results of your spreadsheet model (such as "profit") but they can be any cells, anywhere in your spreadsheet. To select outputs, simply highlight the cell or range of cells you want as outputs in your worksheet and then click the Add Output icon — the one with the red down arrow.

Listing all Outputs and Distribution Functions

The Model window displays all selected outputs and distribution functions in your spreadsheet model.



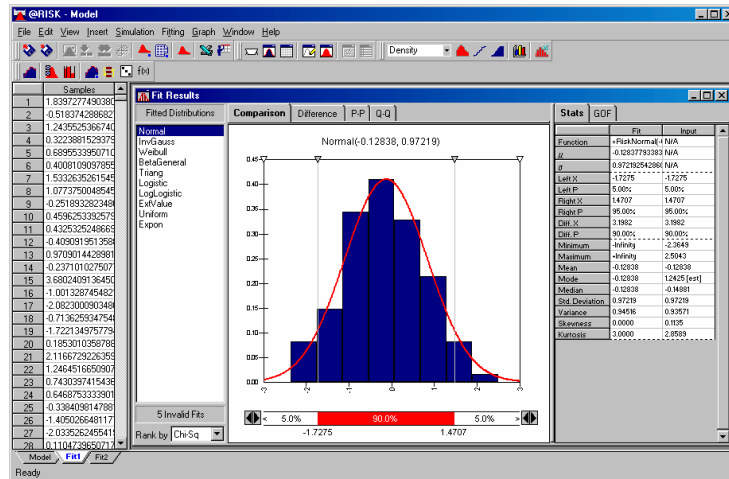
This “Explorer-style” list on the left of the Model window allows you to:

- **Edit any input distribution or output by simply clicking on output or input in Explorer.**
- **Quickly graph and display all defined inputs.**
- **Enter correlations between input distributions.**

Using Data to Define Probability Distributions

The @RISK Model window (Professional and Industrial versions only) also allows you to fit probability distributions to your data. Fitting is done when you have a set of collected data that you want to use as the basis for an input distribution in your spreadsheet. For example, you may have collected historical data on a product price and you might want to create a distribution of possible future prices that is based on this data. Fitting is done using the integrated capabilities of BestFit, a distribution fitting product also available from Palisade.

Distribution Fitting Window



If desired, the distributions which result from a fit can be assigned to an uncertain value in your spreadsheet model. In addition, if data in Excel is used in a fit, it can be "hot-linked" so that the fit will automatically update whenever your data changes.

Running a Simulation

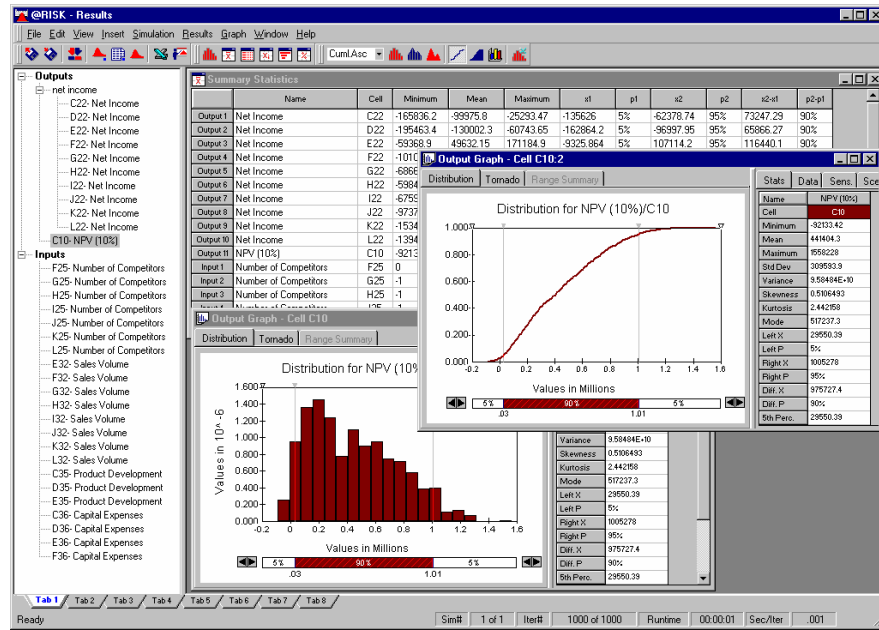
When a risk analysis is run, your spreadsheet is calculated over and over again — where each recalculation is a "**iteration**" — with a set of new possible values sampled from each input distribution each iteration. Each iteration the spreadsheet is recalculated with the new set of sampled values and a new possible result is generated for your output cells.

As a simulation progresses, new possible outcomes are generated each iteration. @RISK keeps track of these output values. A distribution of possible outcomes is created by taking all the possible output values generated, analyzing them and calculating statistics on how they are distributed across their minimum-maximum range.

Simulation Results

@RISK simulation results include distributions of possible results for your outputs. In addition, @RISK generates sensitivity and scenario analysis reports which identify the input distributions most critical to your results. These results are best presented graphically. Available graphs include frequency distributions of possible output variable values, cumulative probability curves and summary graphs which summarize changing risk across a range of output cells.

Graphs and Reports Generated by an @RISK Simulation in the Results Window



Simulation reports and graphs generated in the Results window are interactive, so you can easily manipulate graphs and reports to assess probabilities of different outcomes occurring. You can also easily change graph types, overlay graphs on each other for comparison and perform other interactive reviews of simulation results.

Reporting in the Results window vs. in Excel

@RISK graphs and reports can be displayed either directly in your spreadsheet or in the Results window as shown above. If you select to get simulation reports directly in Excel, a new workbook can be generated containing the reports you select.

**Reports
Generated in
Excel by an
@RISK
Simulation**

@RISK Summary Report

General Information

Workbook Name	Finance.xls
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	22
Number of Outputs	11
Sampling Type	Latin Hypercube
Simulation Start Time	10/20/01 13:19:04
Simulation Stop Time	10/20/01 13:19:05
Simulation Duration	0:00:01
Random Seed	1736530771

Output and Input Summary Statistics

Output Name	Output Cell	Simulation	Minimum	Maximum	Mean	Std Dev	x1	p1
Net Income	\$C\$22	Finance.xls	\$ (185,591.30)	\$ (13,786.12)	\$ (99,989.43)	\$ 22,448.84	\$ (137,426.75)	
Net Income	\$D\$22	Finance.xls	\$ (206,756.53)	\$ (67,331.84)	\$ (130,013.71)	\$ 20,122.94	\$ (163,292.88)	
Net Income	\$E\$22	Finance.xls	\$ (66,962.72)	\$ 187,524.92	\$ 49,643.91	\$ 35,344.04	\$ (7,868.98)	
Net Income	\$F\$22	Finance.xls	\$ (12,369.66)	\$ 280,264.20	\$ 74,251.95	\$ 57,898.04	\$ 9,087.69	
Net Income	\$G\$22	Finance.xls	\$ (4,984.00)	\$ 314,726.91	\$ 115,182.90	\$ 63,988.77	\$ 31,693.38	
Net Income	\$H\$22	Finance.xls	\$ (7,765.77)	\$ 384,413.28	\$ 125,976.99	\$ 77,918.05	\$ 33,852.59	
Net Income	\$I\$22	Finance.xls	\$ (28,669.07)	\$ 730,978.81	\$ 183,033.74	\$ 133,464.13	\$ 33,121.35	
Net Income	\$J\$22	Finance.xls	\$ (119,740.72)	\$ 961,089.00	\$ 243,036.89	\$ 197,074.33	\$ 33,981.45	
Net Income	\$K\$22	Finance.xls	\$ (144,237.78)	\$ 1,096,950.38	\$ 251,901.00	\$ 213,374.06	\$ 29,977.26	
Net Income	\$L\$22	Finance.xls	\$ (237,639.86)	\$ 1,028,512.13	\$ 257,098.27	\$ 220,219.20	\$ 33,129.07	
NPV (10%)	\$C\$10	Finance.xls	\$ (119,787.33)	\$ 1,240,053.13	\$ 445,551.11	\$ 299,389.64	\$ 28,756.90	

Input Name	Input Cell	Simulation	Minimum	Maximum	Mean	Std Dev	x1	p1
Number of Competitors	\$F\$25	Finance.xls	0	2	1	0.816496581	0	
Number of Competitors	\$G\$25	Finance.xls	1	1	0.001	0.817108734	1	

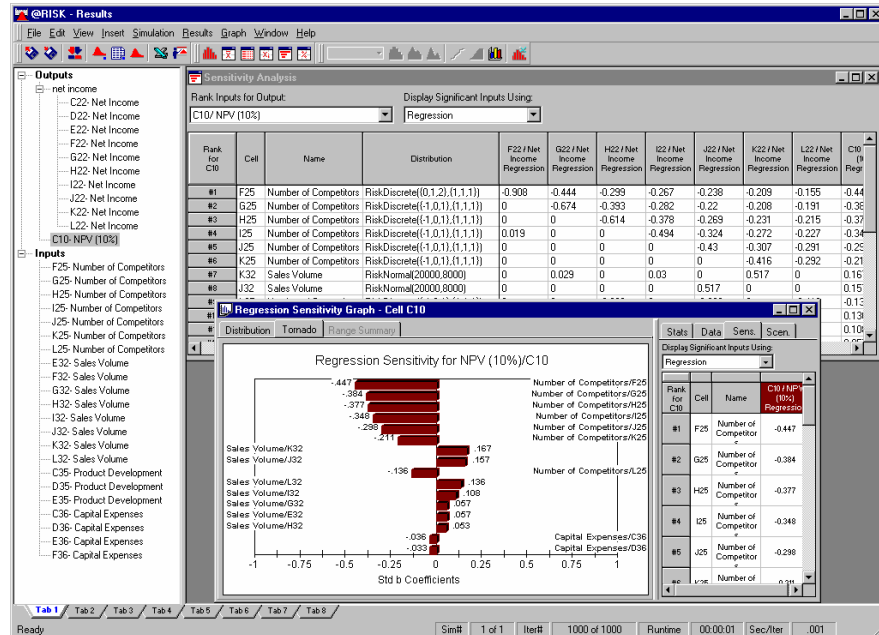
Simulation reports and graphs generated in the Excel window are less interactive than those displayed in the Results window, but you have access to all Excel's capabilities for formatting the graphs and reports. In addition, @RISK reports generated in Excel can use pre-built template sheets that contain custom formatting, titles, logos and more.

Advanced Analytical Capabilities

Advanced capabilities are present in @RISK that allow sophisticated analysis of simulation data. @RISK collects simulation data by iteration for both input distributions and output variables. After completion of the simulation, it analyzes this data set to determine:

- **Sensitivities**, identifying the input distributions which are 'significant' in determining output variable value, and
- **Scenarios**, or the combinations of input distributions which generate output target values.

Sensitivity Analysis



The Sensitivity analysis — which identifies significant inputs — is carried out with two different analytical techniques. The first technique used is a form of regression analysis. With this analysis, sampled input variable values are regressed against output values, leading to a measurement of sensitivity by input variable. The second technique used is a rank correlation calculation. With this analysis, correlation coefficients are calculated between the output values and each set of sampled input values. The results of each form of sensitivity analysis can be displayed as a "tornado" type chart, with longer bars at the top representing the most significant input variables.

Scenario Analysis

The Scenario analysis identifies combinations of inputs which lead to output target values. Scenario analysis attempts to identify groupings of inputs which cause certain output values. This allows simulation results to be characterized by statements such as "when Profit is 'high', significant inputs are low Operating Cost, very high Sales Price, high Sales Volume, etc."

Scenario Analysis

Display Groups of Input Values causing Output Scenarios, using:
Percentile Medians

Input#	Cell	Name	K22/Net Income Percentile	K22/Net Income Percentile	K22/Net Income Percentile	L22/Net Income Percentile	L22/Net Income Percentile	L22/Net Income Percentile	C10/Net Income Percentile	C10/Net Income Percentile	C10/Net Income Percentile
			>75%	<25%	>90%	>75%	<25%	>90%	>75%	<25%	>90%
#1	F25	Number of Competitors	--	--	33.4%	--	--	--	33.4%	100%	33.4%
#2	G25	Number of Competitors	--	--	--	--	--	--	--	100%	--
#3	H25	Number of Competitors	--	100%	--	--	--	33.4%	33.4%	100%	33.4%
#4	J25	Number of Competitors	--	100%	33.4%	--	--	--	33.4%	--	33.4%
#5	K25	Number of Competitors	33.4%	100%	33.4%	33.4%	--	33.4%	33.4%	--	33.4%
#6	L25	Number of Competitors	--	--	--	33.3%	100%	33.3%	--	--	33.3%
#7	E32	Sales Volume	--	--	--	--	--	--	--	--	--
#8	F32	Sales Volume	--	--	--	--	--	--	--	--	--
#9	G32	Sales Volume	--	--	--	--	--	--	--	--	--
#10	H32	Sales Volume	--	--	--	--	--	--	--	--	--
#11	I32	Sales Volume	--	--	--	--	--	--	--	--	--
#12	J32	Sales Volume	--	--	--	--	--	--	--	--	--
#13	K32	Sales Volume	--	21.4%	84.65206%	--	--	--	--	--	71.14758%
#14	L32	Sales Volume	--	--	--	--	21.7%	82.24299%	--	--	77.19838%
#15	C35	Product Development	--	--	--	--	--	--	--	--	--
#16	D35	Product Development	--	--	--	--	--	--	--	--	--
#17	E35	Product Development	--	--	--	--	--	--	--	--	--
#18	C36	Capital Expenses	--	--	--	--	--	--	--	--	--
#19	D36	Capital Expenses	--	--	--	--	--	--	--	--	--
#20	E36	Capital Expenses	--	--	--	--	--	--	--	--	--
#21	F36	Capital Expenses	--	--	--	--	--	--	--	--	--

Setting Up and Simulating an @RISK Model

Now that you have a quick overview as to how @RISK works, let's step through the process of setting up an @RISK model in your spreadsheet and running a simulation on it. We'll touch briefly on:

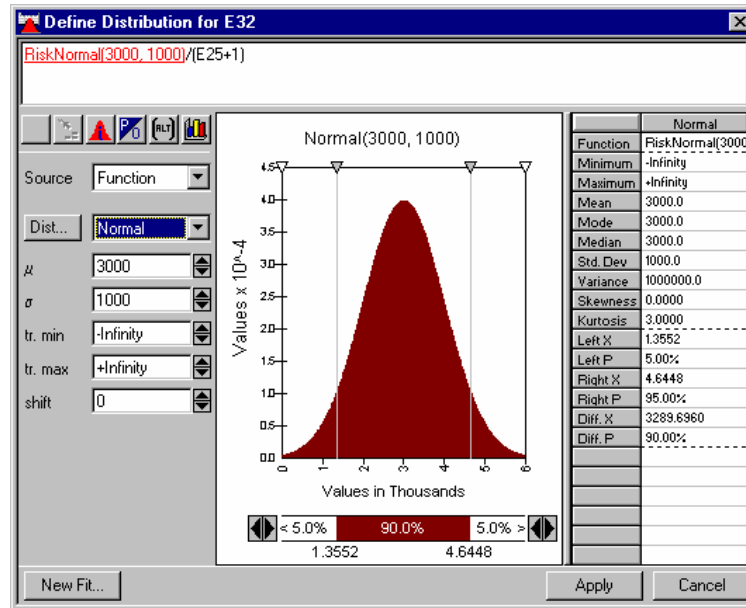
- *Probability Distributions in Your Worksheet*
- *Correlations Between Distributions*
- *Running a Simulation*
- *Simulation Results*
- *Graphs of Simulation Results*

Probability Distributions in Your Worksheet

As previously mentioned, uncertainty in an @RISK model is entered with distribution functions. You can choose from over thirty different functions when entering uncertainty in your spreadsheet. Each function describes a different type of probability distribution. The simplest functions are those such as TRIANG(min,most likely,max) or UNIFORM(min,max) which take arguments specifying the minimum, most likely or maximum possible value for the uncertain input. More complex functions take arguments specific to the distribution — such as BETA(alpha,beta).

For more sophisticated models, @RISK allows you to set up distribution functions which use cell references and spreadsheet formulas for function arguments. Many powerful modeling features can be created by using these types of functions. For example, you can set up a group of distribution functions across a spreadsheet row, with the mean of each function determined by the value sampled for the prior function. Mathematical expressions can also be used as arguments for distribution functions.

Distributions in the Pop-Up Window



All distribution functions can be defined and edited using the pop-up Define Distribution window. The Define Distribution window can also be used to enter multiple distribution functions in a cell's formula, enter names that will be used to identify an input distribution, truncate a distribution, fit distributions to data and use a fit result as a distribution in a cell and more. Multiple distribution functions in a cell formula can be assigned and edited using the Define Distribution window.

Define Distribution Window and Resulting Functions in Excel

All entries made in the Define Distribution Window are converted to distribution functions that are placed in your spreadsheet. For example, the distribution function created by the entries in the window displayed here would be:

`=RiskNormal(3000,1000,RiskTruncate(1000,5000))`

Thus, all the distribution arguments that are assigned through the Define Distribution window can also be entered directly in the distribution itself. In addition, all arguments can be entered as cell references or as formulas, just as are standard Excel functions.

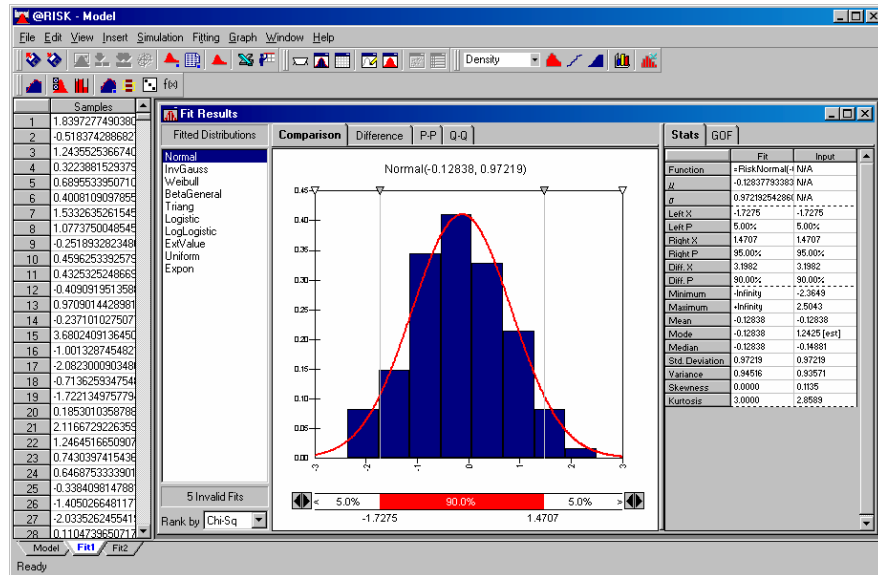
It often helps to first use the Define Distribution window to enter your distribution functions to better understand how to assign values to function arguments. Then, once you better understand the syntax of distribution function arguments, you can enter the arguments yourself directly in Excel, bypassing the Define Distribution window.

Note: @RISK distribution functions have both required and optional arguments. The only required arguments are the numeric values which define the range and shape of the distribution. All other arguments, such as name, truncation, correlation and others, are optional and can be entered only when needed.

Fitting Distributions To Data

The @RISK Model window also allows you to fit probability distributions to your data (Professional and Industrial versions only). Fitting is done when you have a set of collected data that you want to use as the basis for an input distribution in your spreadsheet. For example, you may have collected historical data on a product price and you might want to create a distribution of possible future prices that is based on this data. You can also quickly fit data and assign a fit result to a distribution in your model by clicking the New Fit button in the Define Distribution window.

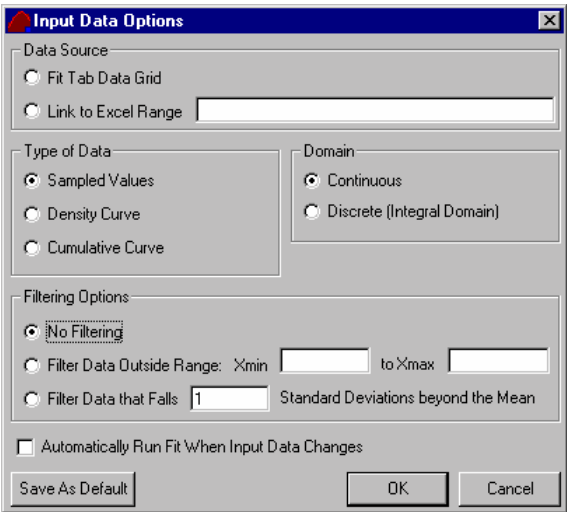
Distribution Fitting Window



The distributions which result from a fit are listed in the Fit Result window and the comparison of each fitted distribution with the underlying data can be displayed by clicking through the list.

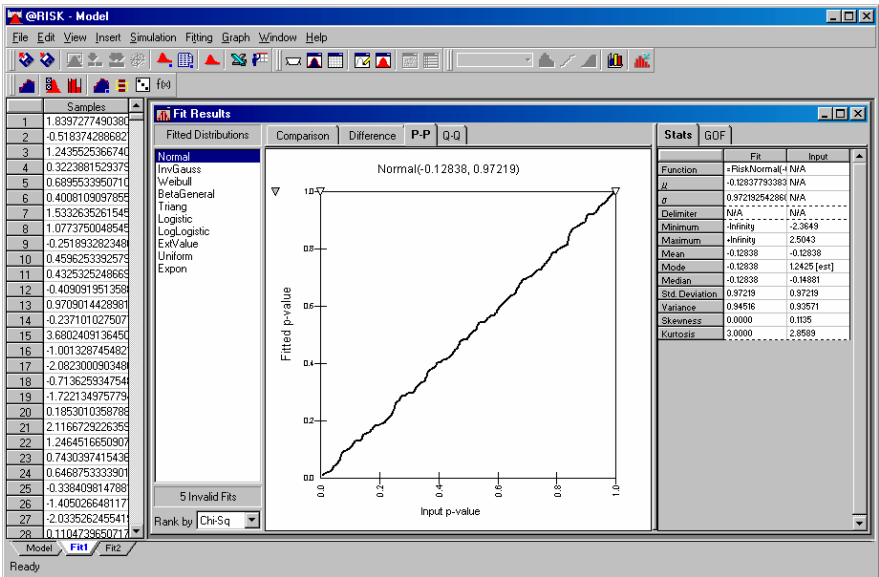
Fitting Options

A variety of options are available for controlling the fitting process. Specific distributions can be selected to be fit. In addition, input data can be in the form of sample, density or cumulative data. You can also filter your data prior to fitting.



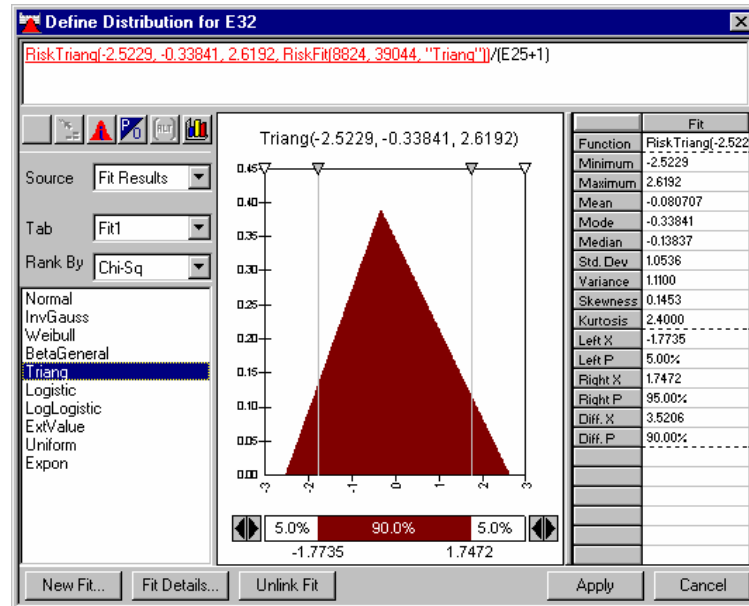
Fit Reports

Comparison, Difference, P-P and Q-Q plots are available to help you examine the results of your fits. Delimiters on graphs allow you to quickly calculate probabilities associated with values in fitted distributions.



Fitting Data to Define a Distribution

The Define Distribution window allows you to quickly fit distributions to data in Excel and use the distributions from the fit in your model. Clicking New Fit from the pop-up window allows you to quickly identify data in Excel, run a fit and then assign a resulting distribution to an uncertain value in your model.



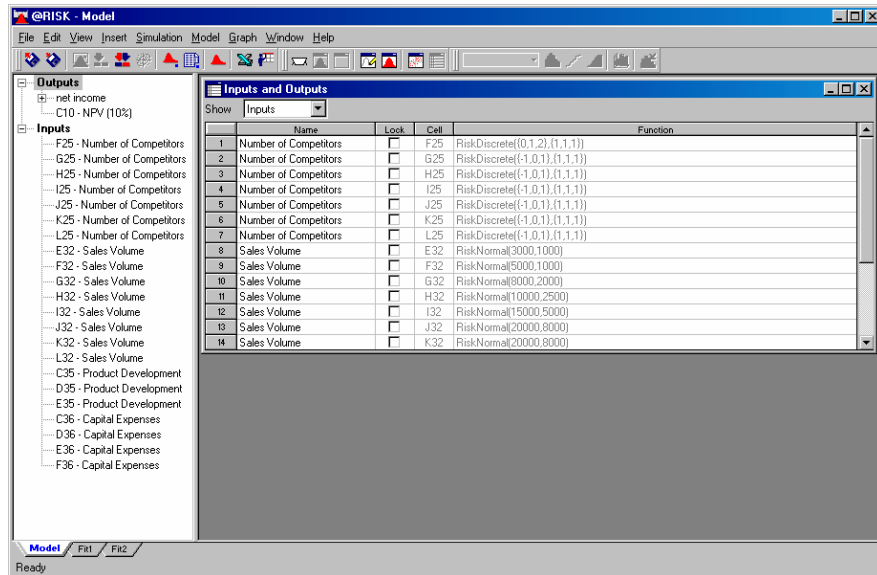
Data in Excel can then be "linked" to your fit. If the data changes, your fit will automatically update and the distribution function from the new fit result will be placed in your model!



List Icon

**Input
Distribution
Functions in
Worksheet
FINANCE**

To help you view your model, @RISK detects all distribution functions entered in your worksheet and places them in the Explorer list in the @RISK Model window. This list summarizes all the distribution functions you have entered, with their location and "name", so you can clearly see how you have defined the uncertainty in your model. Clicking the List icon in the @RISK Toolbar in Excel — the one with a red and blue arrow — displays the Model Window with the Outputs and Inputs list, along with a window that summarizes all input distributions and outputs that have been selected.



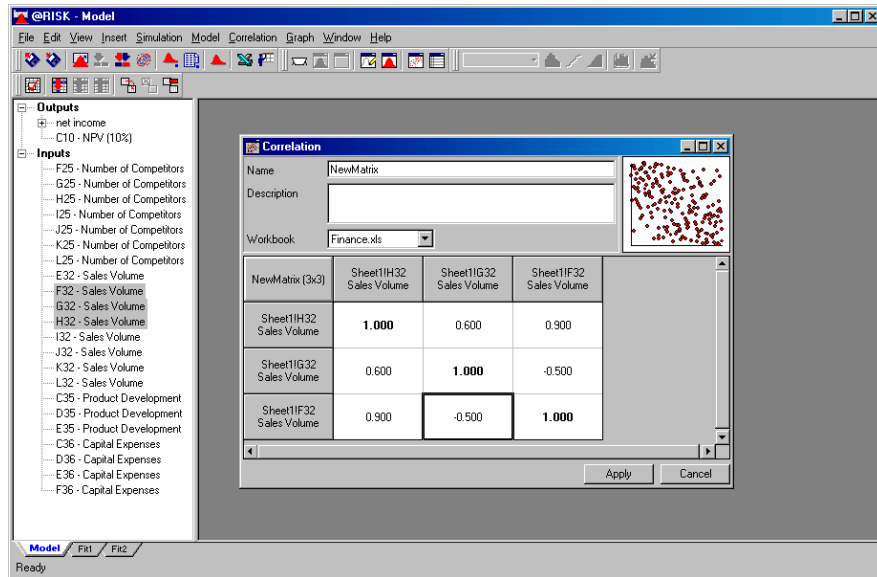
Using the Explorer style Outputs and Inputs list in the Model window, you can review and edit all the distribution functions you have entered. It is easy to graph all your input distributions at once for comparison or presentation purposes.

In the Model window all distribution functions can be edited just as if they were displayed in the Define Distribution pop-up window. Changes made to distributions are automatically written to your spreadsheet formulas.

Correlating Input Variables

During a simulation analysis it is important to account for correlation between input variables. Correlation occurs when the sampling of two or more input distributions are related — for example, when the sampling of one input distribution returns a relatively "high" value, it may be that sampling a second input should also return a relatively high value. A good example is the case of one input named "Interest Rate" and a second input called "Housing Starts". There may be a distribution for each of these input variables, but the sampling of them should be related to avoid nonsensical results. For example, when a high Interest Rate is sampled, Housing Starts should be sampled as relatively low. Conversely, you would expect that when Interest Rates are low, Housing Starts should be relatively high.

Correlation Matrix



Correlations in the Model Window

The Model window allows you to specify correlations between your inputs through correlation matrices. The Explorer list has a heading Correlations (along with Outputs and Inputs) that expands to show all correlation matrices you have defined.

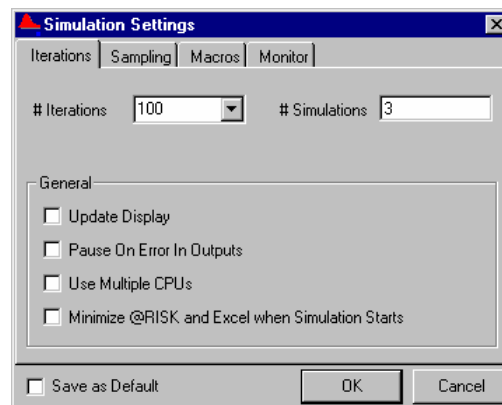
Matrices are defined in the Model window by selecting input distributions in the inputs list and selecting the Model menu Correlate Inputs command. Inputs may also be dragged from the Explorer list onto a pre-existing matrix. Then, you can assign the correlation coefficients between these inputs in the displayed matrix. Correlation coefficients can be between -1 and 1, with -1 specifying complete negative correlation of the sampling of two inputs and 1 specifying complete positive correlation of the sampling of two inputs.

As with the Define Distribution window, correlation matrices entered in the Model window cause @RISK functions to be entered in your spreadsheet model. A sheet named **@RISK Correlations** is also created in Excel that displays your entered matrix. RiskCorrmat functions are added that contain all the correlation information that was entered in your matrix. Once you see the RiskCorrmat entries that are created by the Model window and are comfortable with their syntax, you can enter these functions yourself directly in your spreadsheet, bypassing the Model window.

Simulation Settings

A variety of settings may be used to control the type of simulation @RISK performs. A simulation in @RISK supports unlimited iterations and multiple simulations. Multiple simulations allow you to run one simulation after another on the same model. In each simulation you can change values in your spreadsheet so you can compare simulation results under different assumptions.

Available Simulation Settings

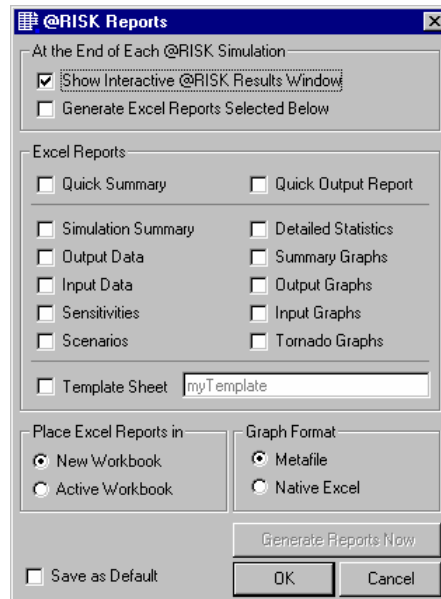


In addition, simulation settings allow you to select either Latin Hypercube or Monte Carlo sampling types. The update of the spreadsheet display may be turned on or off as desired.

In the Macros tab, you can specify Excel spreadsheet macros to run 1) before a simulation, 2) after a simulation, 3) before each iteration's sampling and recalc and 4) after each iteration's sampling and recalc. This allows custom applications created with the spreadsheet macro language to be integrated with @RISK.

Reporting

Simulation results may be reported in the interactive @RISK Results window or directly in Microsoft Excel. The Reports icon on the @RISK toolbar in Excel allows you to select the type of reporting you want.



When reports are placed directly in Microsoft Excel, you can select to use templates for each report that is generated. These templates can contain custom formatting and titles.

Running a Simulation

A simulation in @RISK involves repetitive recalculations of your worksheet. Each recalculation is called an "iteration". Each iteration:

- *All distribution functions are sampled.*
- *Sampled values are returned to the cells and formulas of the worksheet.*
- *The worksheet is recalculated.*
- *Values calculated for output cells are collected from the worksheet and stored.*

This repetitive recalculation process can run hundreds or thousands of iterations if necessary.



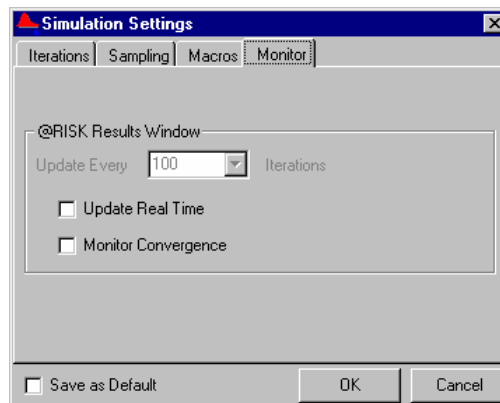
Simulate Icon

Clicking the Simulate icon or selecting the **Simulation menu Start command** starts a simulation. When a simulation is running you can watch Excel recalculate over and over using different sampled values from distribution functions, monitor the convergence of your output distributions and watch graphs of distributions of simulation results update real-time.

Convergence

@RISK includes a convergence monitoring capability to help evaluate the stability of the output distributions during a simulation. As more iterations are run, output distributions become more "stable" as the statistics describing each distribution change less and less with additional iterations. It is important to run enough iterations so that the statistics generated on your outputs are reliable. However, there comes a point when the time spent for additional iterations is essentially wasted because the statistics generated are not changing significantly.

Monitoring Options



@RISK monitors a set of convergence statistics on each output distribution during a simulation. During monitoring, @RISK calculates these statistics for each output at selected intervals (such as every 100 iterations) throughout the simulation. These statistics are then compared with the same statistics calculated at the prior interval during the simulation. The amount of change in statistics due to the additional iterations is then calculated.

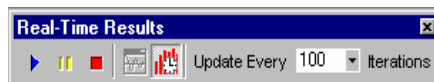
As more iterations are run, the amount of change in the statistics becomes less and less until they "converge" or change less than a threshold percent you set. The statistics monitored on each output distribution are **1) the average percent change in percentile values (0% to 100% in 5% steps), 2) the mean and 3) the standard deviation.**

If desired, @RISK can run in **Auto-Stop** mode. In this case @RISK will continue to run iterations until all outputs have converged. The number of iterations required for output distributions to converge is dependent on the model being simulated and distribution functions included in the model. More complex models with highly skewed distributions will require more iterations than simpler models.

Real-Time Graphs of Results During a Simulation

@RISK also allows you to preview your simulation results as a simulation is running. Selecting the option **Real Time Update of @RISK Results Window** in the Settings dialog causes @RISK to begin updating simulation reports and graphs as the simulation runs. By right-clicking on an output or an input in the Explorer list in the Results window, a real-time graph of simulation results can be displayed. These graphs show how the range and shape of the probability distribution of simulation results for the selected input or output changes as the run proceeds.

Real Time Results Toolbar



Options for controlling Real Time Results are shown on a toolbar in the Results window. Using this toolbar you can change the frequency (in iterations) with which reports and graphs are updated, turn updating on and off, and pause or stop a simulation.

If you select Real Time Results and re-simulate a model, @RISK will update any reports or graphs displayed in the Results window. These windows from the prior simulation will not be closed when a new run starts. This allows you to keep graph formatting and reports consistent run to run.

Simulation Status

@RISK provides on-going monitoring of the progress of a simulation. A counter displays the current iteration# and simulation# and convergence statistics are continuously updated.

An Executing Simulation with Convergence Monitoring and Status Display

Convergence Monitor

Convergence When Statistics Change < 1.5% ☐ Auto-Stop Simulation on Convergence

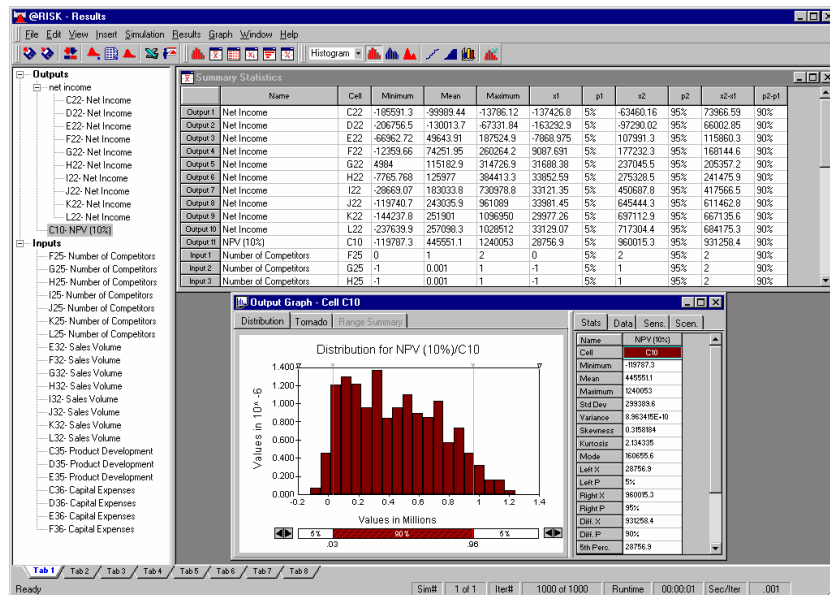
Cell	Name	% Chg in Percs	% Chg in Mean	% Chg in Std Dev	Minimum	Maximum	Mean	Std Dev
C22	Net Income	1.063%	997%	2.196%	-186568.9	-13499.39	-100196	22440.87
D22	Net Income	144%	142%	564%	-192617.7	-69716.14	-130815.6	20455.31
G22	Net Income	1.547%	1.248%	931%	-48615.78	148496.4	50210.04	33328.75
H22	Net Income	2.087%	1.377%	851%	-6219.541	242468.7	76046.13	59124.04
I22	Net Income	2.114%	1.214%	1521%	3578.361	301530.9	115633.4	67742.6
J22	Net Income	1.046%	1.053%	1.415%	1884.317	361690.8	129955	75539.38
K22	Net Income	-473%	-878%	-1.307%	31564.916	639738.4	191095	139473.2
L22	Net Income	2.145%	2.08%	596%	-197098.2	959725.6	254953	206197.4
M22	Net Income	-0.067722%	622%	254%	-36843.65	1226617	266922	228083.6
N22	Net Income	-3.411%	-1.944%	95%	-26410.42	1135359	265097.2	223338
C10	NPV (10%)	1.003%	694%	179%	-71541.49	1351456	467780.6	317305.6

Simulating... 6% ☐ Sim# 1 of 1 Iter# 600 of 10000 Runtime 00:00:02 Sec/Iter .0033

Results Window

Simulation Statistics

The interactive Results window can be used to display your simulation results. It will be displayed after the run is complete. As with the @RISK Model window, the @RISK Results window has an Explorer list showing all outputs and inputs for which simulation results were collected.



Simulation results generated by @RISK include statistics and data reports for both input and output variables. Statistics generated include minimum and maximum calculated values, mean, standard deviation and percentiles. Simulation data can also be displayed by iteration, with all sampled input values and calculated output values shown.

Results Window Toolbars



The Results window toolbar allows you to quickly display simulation reports on screen. The Summary Statistics icon displays summary statistics by output and input variable. The Detailed Statistics icon displays detailed statistics for each variable. The Data icon shows calculated output values and sampled input values by iteration. The Sensitivity icon displays sensitivity analysis results for each output. The Scenario Analysis icon displays scenario analysis results for each output.

Statistics Display

Summary Statistics

Name	Cell	Minimum	Mean	Maximum	s1	p1	s2	p2	s2-s1	p2-p1
Output 1 Net Income	C22	-186568.9	-100709.8	-13499.39	-138072.3	5%	63514.75	95%	74557.59	90%
Output 2 Net Income	D22	-192719.8	-130080.1	-61584.79	-163844	5%	-95593.06	95%	68250.13	90%
Output 3 Net Income	E22	-60530.78	49850.66	158614.5	-8375.776	5%	107248.8	95%	115624.6	90%
Output 4 Net Income	F22	-10399.67	75141.54	252471.5	9783.847	5%	182704.6	95%	172920.8	90%
Output 5 Net Income	G22	-11995.65	114695.3	337556.5	33029.57	5%	238335.9	95%	205306.3	90%
Output 6 Net Income	H22	1884.317	124408.1	379630.2	34768.81	5%	268505.7	95%	233736.8	90%
Output 7 Net Income	I22	67138.36	188673.3	642850.7	36824.06	5%	449840.5	95%	412216.5	90%
Output 8 Net Income	J22	449410.9	248122.2	1051340	29990.44	5%	658028.3	95%	628037.9	90%
Output 9 Net Income	K22	-277962.9	252507.7	1226617	29674.53	5%	674705.8	95%	645031.3	90%
Output 10 Net Income	L22	-277915.2	259719.5	1138237	30825.27	5%	733678.3	95%	702853.1	90%
Output 11 NPV (10%)	C10	-71541.49	446845.4	1360408	26213.03	5%	977536.3	95%	949323.3	90%
Input 1 Number of Competitors	F25	0	0.9866667	2	0	5%	2	95%	2	90%
Input 2 Number of Competitors	G25	-1	2.91687E-01	-1	-1	5%	1	95%	2	90%
Input 3 Number of Competitors	H25	-1	-0.0125	1	-1	5%	1	95%	2	90%
Input 4 Number of Competitors	I25	-1	6.666667E-01	-1	-1	5%	1	95%	2	90%
Input 5 Number of Competitors	J25	-1	-0.01625	1	-1	5%	1	95%	2	90%

Detailed Statistics

Name	Net Income	Net Income	Net Income	Net Income	Net Income	Net Income
Description	Output	Output	Output	Output	Output	Output
Cell	C22	D22	E22	F22	G22	H22
Minimum	-186568.9	-192719.8	-60530.78	-10399.67	-11995.65	1884.317
Maximum	-13499.39	-61584.79	158614.5	252471.5	337556.5	379630.2
Mean	-100709.8	-130080.1	49850.66	75141.54	114695.3	124408.1
Std Deviation	22765.04	20500.98	34708.66	59661.44	65901.93	74665.58
Variance	5.162471E+08	4.202301E+08	1.204691E+09	3.476450E+09	4.326894E+09	5.574948E+09
Skewness	2.594054E-02	3.443711E-02	-3.302955E-02	0.727553	0.7290493	0.800703
Kurtosis	2.947297	2.975767	2.886147	2.2364	2.732867	2.781842
Errors Calculated	0	0	0	0	0	0
Mode	-96067.38	-131999.4	51836.35	193851.1	64670.11	69400.96
5% Perc	-138072.3	-163844	-8375.776	9783.847	33029.57	34768.81
10% Perc	-130426.9	-155405.6	4197.835	15134.97	41401.38	44651.84
15% Perc	-125023.3	-150953.9	13113.71	18836.25	49572.69	52893.75
20% Perc	-120319.6	-147411.3	19649.35	22254.67	55862.47	59553.79

Targets

Target values can be calculated on simulation results. A target shows the probability of achieving a specific outcome or the value associated with any probability level. Using targets you can answer questions such as "What is the chance of a result greater than one million?" or "What is the chance of a negative outcome?". Targets can be entered in the Summary Statistics window, the Detailed Statistics window, and can be set directly using delimiters on graphs of simulation results.

Summary Statistics

Name	Cell	Minimum	Mean	Maximum	s1	p1	s2	p2	s2-s1	p2-p1
Output 1 Net Income	C22	-169522.2	-99966.89	-36982.77	-140774.2	6%	-48857.4	99%	91916.8	93%
Output 2 Net Income	D22	-185285.5	-129981.5	-74973.65	-161362.8	6%	-80834.79	99%	80528.02	93%
Output 3 Net Income	E22	-42462.9	49598.38	141915.9	-5934.496	6%	131319	99%	137253.5	93%
Output 4 Net Income	F22	-14272.39	73319.97	207320.8	12717.85	6%	206804.6	99%	194086.8	93%
Output 5 Net Income	G22	18273.35	114798.5	274919.6	34992.98	6%	264371.4	99%	229378.4	93%
Output 6 Net Income	H22	19599.45	117101.1	336099.1	36603.56	6%	314398.8	99%	277795.3	93%
Output 7 Net Income	I22	-4891.806	166383.8	574116.3	41564.15	6%	520079	99%	478514.8	93%
Output 8 Net Income	J22	-16450.19	248226.8	1021700	27906.59	6%	903145	99%	875238.4	93%
Output 9 Net Income	K22	-86345.05	246877.5	797111.1	37454.53	6%	758576.4	99%	721121.9	93%
Output 10 Net Income	L22	-40638.29	272404.3	1061233	32647.86	6%	982284.5	99%	949636.6	93%
Output 11 NPV (10%)	C10	6476.081	437326.7	1252256	40359.03	6%	1201378	99%	1161019	93%
Input 1 Number of Competitors	F25	0	1	2	0	6%	2	99%	2	93%
Input 2 Number of Competitors	G25	-1	-0.01	1	-1	6%	1	99%	2	93%
Input 3 Number of Competitors	H25	-1	-0.01	1	-1	6%	1	99%	2	93%
Input 4 Number of Competitors	I25	-1	0.01	1	-1	6%	1	99%	2	93%

By entering a desired target – such as 99% - for an output in the Summary Statistics window and copying it across all outputs, you can quickly see the same target calculated for all simulation results.

Filters

Filters can be used to remove unwanted values from statistics calculations and graphs. You would use a filter, for example, if you wanted to see statistics on only the positive outcomes in a model. Filters can be entered using the Filter dialog or in the Simulation Statistics window.

The screenshot shows the 'Filter' dialog box with the following components:

- Status of All Filters:** Two radio buttons, 'Enabled' (unselected) and 'Disabled' (selected).
- Filter Settings:** A table with 6 columns: Name, Cell, Type, Minimum, and Maximum. It contains 8 rows of filter settings for 'Net Income'.
- Current Statistics:** A text box showing 'Current: Net Income C22: Min=-162655.8 Mean=-99956.69 Max=-35982.14'.
- Options:** Two checkboxes, 'Show Only Outputs or Inputs with Filters' (unchecked) and 'Same Filters for all Simulations' (unchecked).
- Buttons:** 'Clear Filters', 'Cancel', and 'Apply'.

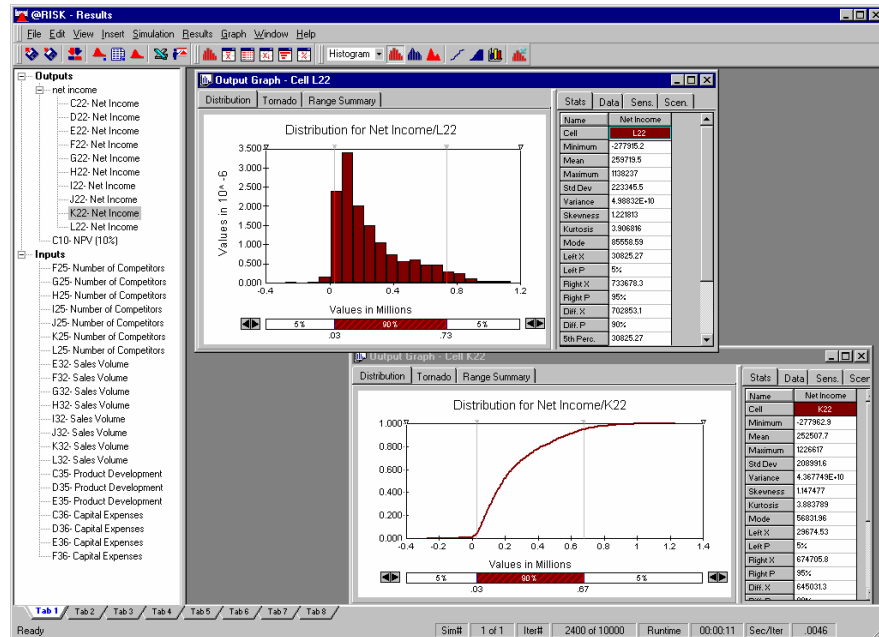
	Name	Cell	Type	Minimum	Maximum
Output 1	Net Income	C22	Std	-Infinity	-100000
Output 2	Net Income	D22	Off		
Output 3	Net Income	E22	Off		
Output 4	Net Income	F22	Off		
Output 5	Net Income	G22	Off		
Output 6	Net Income	H22	Std	125000	+Infinity
Output 7	Net Income	I22	Off		
Output 8	Net Income	J22	Off		

Graphing Results

Simulation results are easily expressed with graphs. Right-clicking any output or input in the Explorer list in the Results window allows you to graph the simulation results for the selected output or input.

A graph of the results for an output shows the range of possible outcomes and their relative likelihood of occurrence. This type of graph may be displayed in standard histogram or frequency distribution form. Distributions of possible outcomes may also be displayed in cumulative form.

Simulation Results in Histogram and Cumulative Format



Each graph created by @RISK is displayed in conjunction with the statistics, data, sensitivity and scenario results for the output or input that is graphed. The type of graph displayed may be changed using the icons in the Graph toolbar. In addition, by clicking the right mouse button on a graph window, a pop-up menu is displayed with commands that allow the changing of a graph's format, scaling, colors, titles and other characteristics. Each graph may be copied to the clipboard and pasted into your spreadsheet. As graphs are transferred as Windows metafiles, they may be resized and annotated once pasted into a spreadsheet.

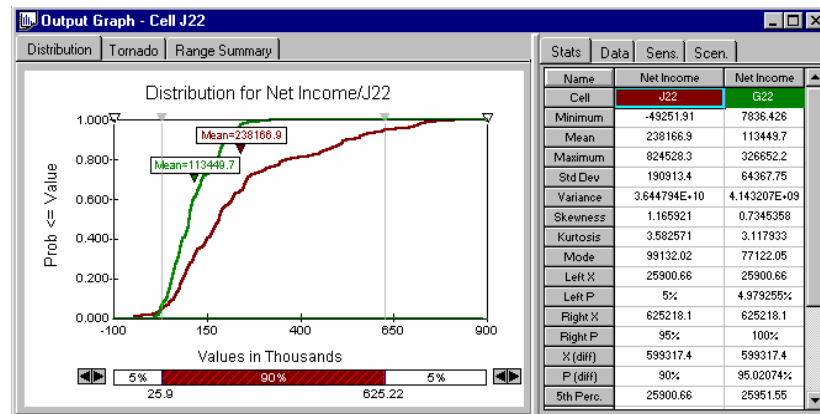
Using the **Graph in Excel** command, graphs can be drawn in Excel's native graph format. These graphs can be changed or customized just as with any Excel graph.

Delimiters

By dragging the delimiters displayed on a histogram or cumulative graph, target probabilities may be calculated. When delimiters are moved, calculated probabilities are shown both in the delimiter bar beneath the graph and in the displayed statistics report. This is useful for graphically displaying answers to questions such as “What is the probability of a result between 1 million and 2 million occurring?” and “What is the probability of a negative result occurring?”.

Overlaying Graphs for Comparison

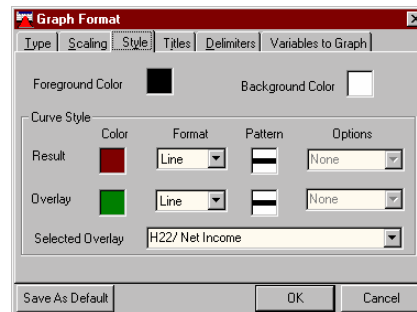
Many times it is useful to compare several simulated distributions graphically. This can be done using overlay graphs.



Overlays are added by using the **Overlay on Active Graph** command on the Explorer right-click popup menu. Once overlays are added, delimiter statistics display probabilities for all distributions included in the overlay graph. Data, sensitivities and scenarios are also displayed for all overlays.

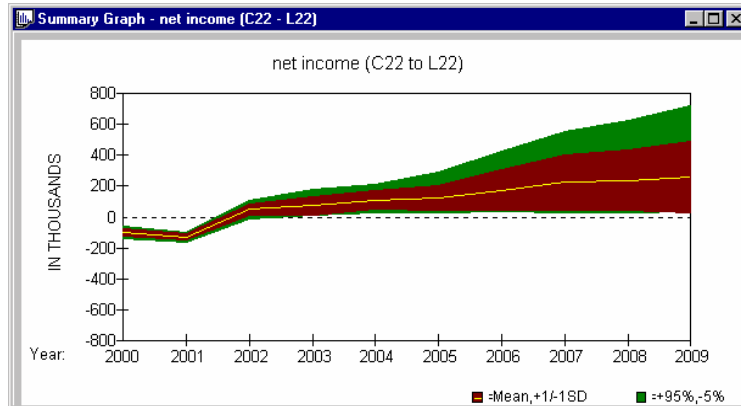
Formatting Graphs

Each distribution in an overlay graph can be formatted independently. By using the **Style** tab options in the **Graph Format** dialog box, the color, style and pattern of each curve in the overlay graph may be set.



Summary Graphs

Where output variables have been selected as a "range" of cells — that is, you select a range of spreadsheet cells and click the "Add Output" button — summary graphs of risk are created following a simulation. A Summary graph displays how risk changes across a range of output cells.



A Summary graph is especially useful in displaying trends such as how risk changes across time. If, for example, a range of 10 output cells contained Profit in years 1 through 10 of a project, the Summary graph for this range shows how your risk changed across the 10 year period. The narrower the band, the less the uncertainty about your Profit estimates. Conversely, the wider the band the greater the possible variance in Profit and the greater the risk.

The center line of the Summary graph represents the trend in mean value across the range. The two outer bands above the mean are 1 standard deviation above the mean and the 95th percentile. The two outer bands below the mean are one standard deviation below the mean and the 5th percentile. The definition of these bands can be changed using the **Type** tab in the **Graph Format** dialog box.

Sensitivity analysis results are displayed by clicking the **Insert New Sensitivity Window** icon. These results show the sensitivity of each output variable to the input distributions in your worksheet. This identifies the most "critical" inputs in your model. These are the inputs you should concentrate on most when making plans based on your model.

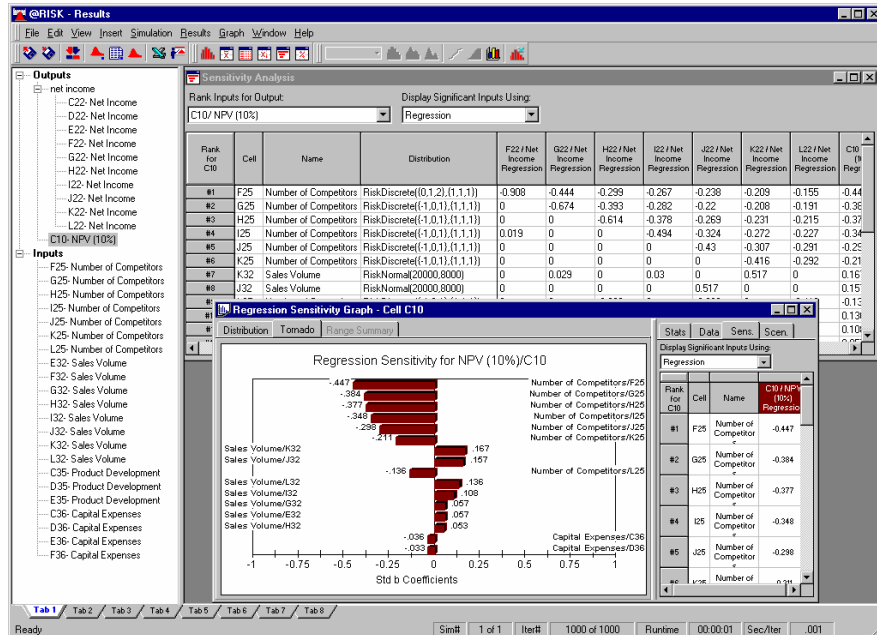
The data displayed in the Sensitivity window is ranked for the output selected in the **Rank Inputs for Output:** entry window. The sensitivity of all other outputs to the ranked inputs is also shown.

In the regression analysis, the coefficients calculated for each input variable measure the sensitivity of the output to that particular input distribution. The overall fit of the regression analysis is measured by the reported fit or R-squared of the model. The lower the fit the less stable the reported sensitivity statistics. If the fit is too low — beneath .5 — a similar simulation with the same model could give a different ordering of input sensitivities.

The sensitivity analysis using rank correlations is based on the Spearman rank correlation coefficient calculations. With this analysis, the rank correlation coefficient is calculated between the selected output variable and the samples for each of the input distributions. The higher the correlation between the input and the output, the more significant the input is in determining the output's value.

Tornado Graph

Sensitivity results are graphically displayed in tornado graphs. A tornado graph can be generated by right-clicking any output in the Explorer list or selecting the Tornado Graph tab in a displayed graph window.



Scenario Analysis Results

The Scenarios Window icon displays the Scenario analysis results for your output variables. Up to three scenario targets may be entered for each output variable.

Scenario Analysis											
Display Groups of Input Values causing Output Scenarios, using:											
Percentile Medians											
Input#	Cell	Name	I22 / Net Income Percentile	I22 / Net Income Percentile	I22 / Net Income Percentile	J22 / Net Income Percentile	J22 / Net Income Percentile	J22 / Net Income Percentile	K22 / Net Income Percentile	K22 / Net Income Percentile	K22 / Net Income Percentile
Scenario=			>75%	<25%	>90%	>75%	<25%	>90%	>75%	<25%	>90%
#1	F25	Number of Competitors	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#2	G25	Number of Competitors	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#3	H25	Number of Competitors	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#4	I25	Number of Competitors	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#5	J25	Number of Competitors	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#6	K25	Number of Competitors	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#7	L25	Number of Competitors	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#8	E32	Sales Volume	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#9	F32	Sales Volume	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#10	G32	Sales Volume	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#11	H32	Sales Volume	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#12	I32	Sales Volume	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%
#13	J32	Sales Volume	33.3%	100%	33.3%	33.3%	100%	33.3%	33.3%	100%	33.3%

***How is a
Scenario
Analysis
Performed?***

The Scenario analysis performed on output variable targets is based on a conditional median analysis. In performing the Scenario analysis, first @RISK subsets the iterations of the simulation into only those iterations in which the output variable achieves the entered target. It then analyzes the values sampled for each input variable in those iterations. @RISK finds the median of this "subset" of sampled values for each input and compares that with the median of the input for all iterations.

The objective of this process is to find those inputs whose subset or conditional median differs significantly from the overall median. If the subset median for the input variable is close to the overall median, the input variable is marked as insignificant. This is because the values sampled for the input in the iterations where the target is achieved do not differ markedly from those sampled for the input for the entire simulation. However, if the subset median for the input variable deviates significantly from the overall median (i.e. at least 1/2 a standard deviation) the input variable is significant. The reported scenarios show all inputs which were significant in meeting the entered target.

Reporting in Excel

When you generate simulation reports and graphs in Excel, you have access to all Excel's formatting. In addition, @RISK reports generated in Excel can use pre-built @RISK template sheets that contain custom formatting, titles, logos and more.

Microsoft Excel - Book7

@RISK Summary Report

General Information

Workbook Name	Finance.xls
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	22
Number of Outputs	11
Sampling Type	Latin Hypercube
Simulation Start Time	10/20/01 13:19:04
Simulation Stop Time	10/20/01 13:19:05
Simulation Duration	0:00:01
Random Seed	1736530771

Output and Input Summary Statistics

Output Name	Output Cell	Simulation	Minimum	Maximum	Mean	Std Dev	x1	p1
Net Income	\$C\$22	Finance.xls	\$ (185,591.30)	\$ (13,786.12)	\$ (99,989.43)	\$ 22,448.84	\$ (137,426.75)	
Net Income	\$D\$22	Finance.xls	\$ (206,756.53)	\$ (67,331.84)	\$ (130,013.71)	\$ 20,122.94	\$ (163,292.88)	
Net Income	\$E\$22	Finance.xls	\$ (66,962.72)	\$ 187,524.92	\$ 49,643.91	\$ 35,344.04	\$ (7,868.96)	
Net Income	\$F\$22	Finance.xls	\$ (12,359.66)	\$ 280,264.20	\$ 74,251.95	\$ 57,958.84	\$ 9,087.69	
Net Income	\$G\$22	Finance.xls	\$ 4,984.00	\$ 314,726.91	\$ 115,182.90	\$ 83,988.77	\$ 31,688.38	
Net Income	\$H\$22	Finance.xls	\$ (7,765.77)	\$ 384,413.28	\$ 125,976.99	\$ 77,918.05	\$ 33,852.59	
Net Income	\$I\$22	Finance.xls	\$ (28,669.07)	\$ 730,978.81	\$ 183,033.74	\$ 133,464.13	\$ 33,121.35	
Net Income	\$J\$22	Finance.xls	\$ (119,740.72)	\$ 961,089.00	\$ 243,036.89	\$ 197,074.33	\$ 33,981.45	
Net Income	\$K\$22	Finance.xls	\$ (144,237.78)	\$ 1,096,950.38	\$ 251,901.00	\$ 213,374.06	\$ 29,977.26	
Net Income	\$L\$22	Finance.xls	\$ (237,639.86)	\$ 1,028,512.13	\$ 257,098.27	\$ 220,219.20	\$ 33,129.07	
NPV (10%)	\$C\$10	Finance.xls	\$ (119,787.33)	\$ 1,240,053.13	\$ 445,551.11	\$ 299,389.64	\$ 28,756.90	

Input Name	Input Cell	Simulation	Minimum	Maximum	Mean	Std Dev	x1	p1
Number of Competitors	\$F\$25	Finance.xls	0	2	1	0.81649681	0	
Number of Competitors	\$G\$25	Finance.xls	-1	1	0.001	0.817106724	-1	

Summary Report / Summary Quick Report / Net Income C22 / Net Income D22 / Net Income E22

You can use template sheets to create your own custom simulation report. Simulation statistics and graphs are placed in a template using a set of @RISK functions added to Excel. When a statistics function or graphing function is located in a template sheet, the desired statistics and graphs are then generated at the end of a simulation in a copy of the template sheet to create your report. The original template sheet with the @RISK functions remains intact for use in generating reports from your next simulation.

Template sheets are standard Excel spreadsheets. They are identified to @RISK in the Reports Settings dialog box. These files can also contain any standard Excel formulas so custom calculations can be performed using simulation results.

Chapter 5: @RISK Modeling Techniques

Introduction	93
Models from the book Financial Models Using Simulation and Optimization.....	94
Modeling Interest Rates and Other Trends	95
Projecting Known Values into the Future	97
Modeling Uncertain or "Chance" Events	99
Oil Wells and Insurance Claims	101
Adding Uncertainty Around a Fixed Trend	103
Dependency Relationships.....	105
Sensitivity Simulation	107
Simulating a New Product: The Hippo Example.....	109
Tornado Graphs and Scenarios	115
Finding Value at Risk (VAR) of a Portfolio	119
Simulating the NCAA Tournament.....	123
Remarks	125

Introduction

The *@RISK Modeling Techniques* chapter will show you how to translate typical "risky" situations into @RISK models. These risky situations have been identified from real-life modeling problems that Excel users often encounter. As you use @RISK to analyze uncertainty in your Excel worksheets, look through the examples and illustrations provided in this chapter. You just may find some helpful tips or techniques which will make your @RISK models better representations of uncertain situations.

Seven @RISK techniques are presented here to illustrate common modeling situations under uncertainty. To help you understand the modeling techniques employed, example Excel worksheets and accompanying @RISK simulations are provided with your @RISK system. The simulations are even "pre-run" so you can just look at the results if you like. As you work through each modeling technique discussed, look at the corresponding worksheet and simulation. It will help you understand the @RISK concepts and techniques involved in modeling each risky situation.

The seven modeling techniques illustrated here are:

- **Modeling Interest Rates and Other Trends** - random trends over time and "random walks".
- **Projecting Today's Known Values Into the Future** - an increasingly uncertain future or "increasing variability".
- **Will the Flood Occur or the Competitor Enter the Market?** — modeling uncertain "chance" events.
- **Oil Wells and Insurance Claims** - modeling an uncertain number of events, each with uncertain parameters.
- **"I have to use this projection but don't trust it"** - adding uncertainty around a fixed trend using "error terms".
- **"These values will be affected by what happens someplace else"** - dependency relationships using variable arguments and correlations.
- **Sensitivity Simulation** - how model changes affect simulation results.

Models from the book **Financial Models Using Simulation and Optimization**

In addition to the seven models discussed here, this chapter also includes three @RISK examples from the book **Financial Models Using Simulation and Optimization** by Wayne Winston. These models illustrate how @RISK is applied to everyday business modeling. The full **Financial Models** book includes 63 examples of how @RISK and other add-ins can be applied to a wide variety of financial problems. For more information on purchasing the full Financial Models book, contact Palisade Corporation or visit www.palisade.com.

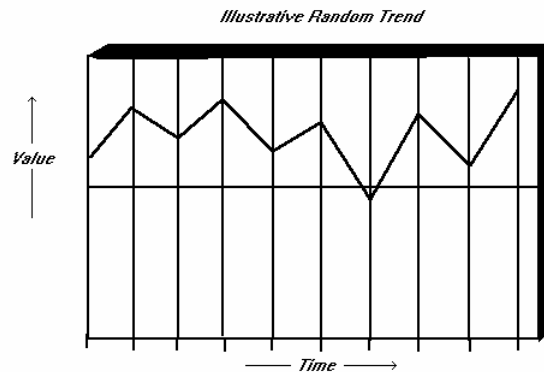
Loading the Example Models

All example spreadsheet models discussed here can be found in the default installation location C:\DTOOLS\RISK45\EXAMPLES.

Modeling Interest Rates and Other Trends

Example Model:RATE.XLS

Whether you are getting a mortgage or evaluating the cost of a variable rate loan, projections of future interest rates are highly uncertain. The movement of the rate of interest you are charged is often viewed as random - moving up and down erratically year to year. This movement may be completely random or it may be a random fluctuation around an underlying known trend. In either case, modeling the random portion of any projection is an important technique in Risk Analysis.



Simulation accounts for randomness in a trend over time in a very powerful way - repetitively trying a different possible series of rates with each iteration of a simulation. For example, you could set up a random trend to project the interest rate over ten years. For each iteration, a new, randomly selected value is chosen for each year's interest rate, and results are calculated. By doing this, simulation includes the effects of all possible future interest rates in your results, instead of just a single, most likely projection.

A "random trend" can be easily and directly included in an Excel worksheet with @RISK. And by using the Excel Copy commands, you can place a random trend anywhere in your worksheet.

Simple Random Trends

The simplest random trend is a distribution copied across time. The value randomly selected in one period is independent of the value selected in any other time period:

- 1) Enter a distribution function for the first cell of the trend
- 2) Copy the distribution over the range of cells

In this case, a new value will be sampled every period - a completely random trend with no correlation over time.

A "Random Walk" with Correlation Period to Period

Maybe you don't think future rates are entirely random. Perhaps next year's rate will be influenced by this year's. In Excel terms, there will be some correlation between one cell in the range and the next. Here's a simple way to model this:

- 1) Enter a distribution function for the first cell in the range.
- 2) Enter a distribution function for the second cell in the range that uses the value sampled for the first cell as one of its arguments (such as its mean or most likely value).
- 3) Copy the formula of the second cell across the range. The referenced argument in the formula is a relative reference - the third cell will use the value in the second as its referenced argument and likewise for the fourth, fifth, etc.

For example:

A1: RiskNormal(100,10)

A2: RiskNormal(A1,10)

A3: RiskNormal(A2,10)

A4: RiskNormal(A3,10)

In this manner there is some correlation between one cell and the next cell in the range.

Refining Your Random Trends

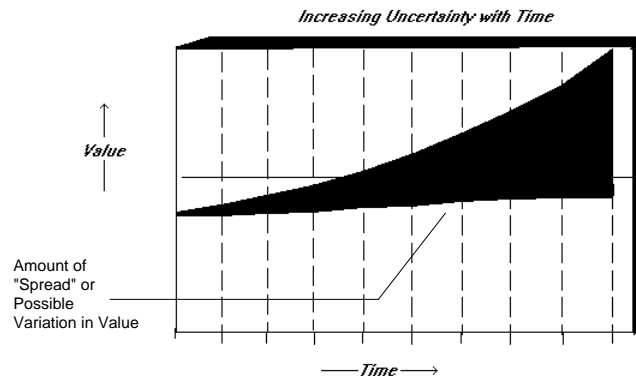
These are just simple examples of modeling random processes over time. As you get more sophisticated, you can include your random terms in formulas which place limits or caps on the amount of change, increase the amount of possible change with time, or other such extensions or variations. And remember, interest rates are just one application for random trends. Look at your Excel worksheets and the uncertain situations you model and you will undoubtedly see others.

Projecting Known Values into the Future

Increasing Uncertainty Over Time

Example Model: VARIABLE.XLS

You know today's values for critical variables in your models, but what about values for these same variables in the future? Time often has a very important impact on estimates - they become less and less certain the further out in time your projections extend. As a consequence, results based on your single "best estimates" become more and more risky the further out in time they are projected.



The widening variation around the trend of best estimates illustrates this problem. @RISK lets you model the effect of time on your estimates by allowing you to easily increase the variability in a random value over time.

The range of possible values for a worksheet cell is given in your distribution functions. As you move out in time - across a range of worksheet cells - the argument of the function which specifies the range of possible values can increase. For example:

A1: RiskLognorm(10,10)

A2: RiskLognorm(10,15)

A3: RiskLognorm(10,20)

A4: RiskLognorm(10,25)

The standard deviation of the LOGNORM distribution function controls the possible variation in value. In this example, as you move out across the range of cells, the standard deviation increases.

Increasing the possible variance in value as your projections extend further and further into the future is a good "rule of thumb" to follow. By doing this, your results will more accurately reflect the greater uncertainty which exists in your knowledge of the distant future.

Modeling Uncertain or "Chance" Events

Will the Flood Occur or the Competitor Enter the Market?

Example Model: DISCRETE.XLS

Uncertainty often shows up in the form of chance events which may have significant impact on your results. Either we will strike oil, or we won't. That competitor will either enter the market or he won't, but if he does! There's a 25% chance of a hailstorm that will wipe out this year's crop.

Including the possibility of these types of events in your models is an important technique in Risk Analysis. If you leave them out, the outcomes caused by these events will not be included in your results and your models will be incomplete. Using the DISCRETE function provided by @RISK and Excel's IF function, modeling these events is easy.

Including the Discrete Event

The DISCRETE function is the means by which you can include probabilities for chance events in your worksheet models.

RiskDiscrete({0,1},{50,50})

This example models the characteristic "coin flip" - the simplest chance event. In this case, an outcome of 0 represents Heads and 1 represents Tails, and each is equally likely to occur. A more complex example illustrates four possible scenarios for annual storm damage from floods:

RiskDiscrete({0,1,2,3},{20,40,30,10})

In this case, outcomes valued 0 to 3 represent four possible levels of flood damage ranging from none (0) through low (1), medium (2) and high (3). The probability of occurrence of no damage is 20%, low 40%, medium 30% and high 10%.

***Including the
Effects of
Chance Events
in Your
Worksheets***

The DISCRETE function returns a value for each iteration that indicates which event has occurred. Your worksheet model has to recognize which event has occurred and calculate different results appropriate to the event. The Excel IF function allows this. Consider the following example and Excel cell entries:

Cell C2 describes an event - the possible entry of a competitor in a given market. There is a 50-50 chance of entry. If entry occurs, your sales level will be 65; if entry does not occur, your sales level will be 100.

C2: RiskDiscrete({0,1},{50,50})

D2: IF(C2=1,100,65)

In the above example, the IF function in cell D2 will return a value of 100 if the outcome in cell C2 is 1 (no entry) and will return 65 if the outcome is 0 (entry). This simple example can be extended throughout your @RISK models. Each iteration of a simulation the DISCRETE function will return one of the possible values. Depending on the value returned, the calculations in your worksheet can change.

Caution

People used to working with single estimates in spreadsheets often substitute discrete distributions where a continuous distribution should be used. For example, they use a discrete distribution to put in three possible price levels where, in reality, price could take any value in a range.

This common mistake occurs because many people are used to manual "what-if" modeling which necessarily limits the user to a small number of discrete estimates. Use a continuous form when any value in a range is possible, and save DISCRETE for event modeling and variables that truly are discrete.

Oil Wells and Insurance Claims

Modeling an Uncertain Number of Events, Each with Uncertain Parameters

Example Model: CLAIMS.XLS

In real life situations, uncertainty often has two or more dimensions. The situation you face may have an uncertain number of events, each of which has an uncertain value. Think, for example, of the insurance industry. An uncertain number of claims may be filed on a new policy. And each claim filed has an uncertain dollar amount. How do you simulate the total claim amount possible? The oil industry faces a similar problem. When drilling oil wells, an uncertain number of wells will be successful. But the amount of oil discovered by each successful well is uncertain. How do you simulate the total amount of oil discovered?

Risk Analysis is very useful in modeling situations such as this. @RISK, combined with the Excel IF function, can provide an easy means of performing such an analysis. It is helpful to review the example simulation, CLAIMS.XLS, while proceeding through this modeling technique.

To model situations where 2 or more levels of uncertainty are present, a worksheet is set up which includes a column of calculations for each of the possible events. For example, if the maximum number of possible claims is 100, 100 columns would be used, each to calculate the results from a single possible claim. A claim # (1-100) would be given at the top of each column.

To run the analysis:

- 1) First, a cell is used to sample the number of events which occur in a given iteration
- 2) The number of events is compared to the # at the top of each column which refers to the calculation of results for a specific event

The number of events sampled is compared to the "claim #" cell at the top of each column. The Excel IF function is used to make the comparison.

For example, if cell A1 holds the *Number of Claims* (sampled from a probability distribution function) and B5 has the *Claim #*.

Number of Claims **A1: 6**

Claim # **B5: 3**

Comparison **B6: IF(B5 <= A1, RiskNormal(100,10), 0)**

The formula in cell B6 says "if the *Claim #* is less than or equal to the *Number of Claims*, return a sample from the normal distribution - otherwise return a value of zero". In the example above, the value in cell B5 is less than the value in A1 so a sample from the normal distribution is returned.

Using this structure, it is possible to evaluate a changing number of events each iteration. And because it is very simple in Excel to copy the calculation for one event across a worksheet, you just have to set up one column of calculations for a single event, then copy it. In the example here, you would set up a column of calculations for Claim #1, and then copy that column across the worksheet to end up with a total number of columns equal to the maximum possible number of events.

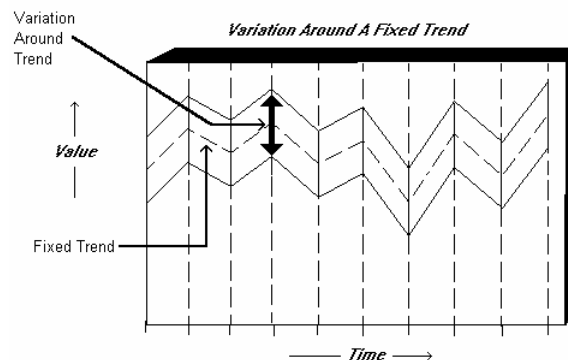
Adding Uncertainty Around a Fixed Trend

I Have To Use This Projection But Don't Trust It

Example Model: ERROR.XLS

Often Excel modelers are given data from other sources for inclusion in their worksheets. "The economics group has provided this projection for GNP growth, so include it in your worksheet model" - could be the guideline. But how often does the future exactly follow even the best projection?

Recognizing the uncertainty inherent to projections, you still may want to stay true to the basic direction offered by the values in the trend. In this case "error terms" let you put a certain amount of variation around the values in the trend. This allows you to examine how variation in trend value will impact your results.



With @RISK, you can easily append an error term to a fixed trend you have already entered in your worksheet. Let's say, for example, that worksheet row B contains the fixed trend in your model. An error term is just a factor you'll multiply each worksheet cell value by. (You also could add an error term to each trend value)

Row B - GNP Growth in Percent

B1: 3.2 * RiskNormal(1,.05)

B2: 3.5 * RiskNormal(1,.05)

B3: 3.4 * RiskNormal(1,.05)

B4: 4.2 * RiskNormal(1,.05)

B5: 4.5 * RiskNormal(1,.05)

B6: 3.5 * RiskNormal(1,.05)

B7: 3.0 * RiskNormal(1,.05)

In this example taken from Excel, the error term for all trend values is drawn from a normal distribution with a mean of 1 and a standard deviation of .05. For each iteration of a simulation, a new error term will be sampled for each cell and will be used to multiply the fixed trend estimate in that cell, allowing variation around the fixed estimate.

An added bonus of an error term is the expected value generated in normal Excel recalculations. Because the expected values of the error terms in the example equal one, they will not affect your normal worksheet recalculations. Thus you can leave the error terms in your formulas and only see their effects when you run your simulations. The same comment holds true if you add, instead of multiply by, the error term. If you add the error term to the fixed estimate, the mean of the error term probability distribution should be zero.

Dependency Relationships

Using Variable Arguments and Correlations — These Values Will Be Affected By What Happens Somewhere Else

Example Models: DEP.XLS, CORRMAT.XLS

Many times you will not know precise argument values for a distribution function in your worksheet. Often the range for a worksheet cell will depend on a value calculated or sampled elsewhere in your model. "If price is low, the range for sales volume is one million to 2 million - but if price is high, the range is only 500,000 to 750,000" is an illustration of this type of dilemma.

Two modeling techniques in @RISK help you to resolve problems such as this, namely (1) *variable arguments for distribution functions* and (2) *correlations in sampling*.

Variable Arguments

The first technique - variable arguments for distribution functions - relies on a standard Excel capability most modelers are familiar with. The referencing of cell addresses in functions is allowed in @RISK just as in Excel. For example:

Minimum **A1: RiskTriang(10,20,30)**

Maximum **B1: RiskNormal(80,10)**

Final Price **C1: RiskUniform(A1,B1)**

This example shows how the range for the uniform distribution for *Final Price* will change with the value sampled for *Minimum* and *Maximum*. Here the range for *Final Price* will change with each iteration of the simulation. *Final Price* thus depends on the variables *Minimum* and *Maximum*.

Correlations in Sampling

The second modeling technique which can be used to affect sampled values based on other calculations in a worksheet is *correlations in sampling*. The @RISK function CORRMAT is used to correlate the values sampled in different distribution functions. This correlation allows you to specify a relationship between the values sampled in different worksheet cells while still maintaining a degree of uncertainty for each.

**Correlating
Interest Rates
and Housing
Starts**

Interest Rate

A1: RiskUniform(6,14, RiskCorrmat (D1: E2,1))

Housing Starts:

B1: RiskUniform(100000,200000, RiskCorrmat (D1: E2,2))

The CORRMAT function is used when you want to have the value sampled for one cell influence the value which is sampled for another. The variable *Interest Rate* - described by the distribution RiskUniform(6,14) - is the distribution that the *Housing Starts* distribution - RiskUniform(100000,200000) - should be correlated with. The range D1:E2 contains a matrix of 4 cells and a single correlation coefficient, -.75. The -.75 is the coefficient which specifies how the two sampled values are correlated. Coefficients range from -1 to 1. A value of -.75 is a negative correlation - as *Interest Rate* goes up, *Housing Starts* go down.

When you are using sampled, uncertain variables in your worksheet models it is important to recognize correlations in sampling. If you don't use methods such as the two presented here, all uncertain variables will be sampled as if they were completely independent of other variables in the model. This can cause erroneous results. Think about what could happen if *Interest Rate* and *Housing Starts* in the above example were completely independent. *Interest Rate* and *Housing Starts* would be sampled entirely independent of one another. A high *Interest Rate* and a high value for *Housing Starts* would be an entirely possible scenario during sampling. But could this happen in real life? Not in this economy!

**Correlating
Multiple
Distributions**

Correlating multiple distribution functions can be accomplished using the CORRMAT function or by selecting the cells containing the distributions in the @RISK Model Window and selecting the **Model menu Correlate Distributions command**. Either of these methods allows you to enter a matrix of correlation coefficients. @RISK then uses the coefficients to correlate the sampling of distribution functions. This is especially useful when pre-existing correlation coefficients (calculated from actual collected data) are available and you want sampling to be governed by those coefficients. Excel can calculate correlations from existing datasets using the CORREL function. For more information on using Correlate or CORRMAT, see the example simulation CORRMAT.XLS.

Sensitivity Simulation

How Do Changes in Model Variables Affect My Simulation Results?

Example Model: SENSIM.XLS

@RISK lets you see the impact of uncertain model parameters on your results. But what if some of the uncertain model parameters are under your control? In this case the value a variable will take is not random, but can be set by you. For example, you might need to choose between some possible prices you could charge, different possible raw materials you could use or from a set of possible bids or bets. To properly analyze your model, you need to run a simulation at each possible value for the "user-controlled" variables and compare the results. A Sensitivity Simulation in @RISK allows you to quickly and easily do this - offering a powerful analysis technique for selecting between available alternatives.

The benefits of Sensitivity Simulation are not limited to evaluating the impacts of user-controlled variables on simulation results. A sensitivity analysis can be run on the probability distributions which describe uncertain variables in your model. You may wish to repetitively re-run a simulation, each time changing the parameters of one (or several) of the distributions in your model. After all the individual simulations are complete, you can then compare the results from each.

The key to a Sensitivity Simulation is the repetitive simulation of the same model while making selected changes to the model each simulation. In @RISK any number of simulations can be included in a single Sensitivity Simulation. The SIMTABLE function is used to enter lists of values, which will be used in the individual simulations, into your worksheet cells and formulas. @RISK will automatically process and display the results from each of the individual simulations together, allowing easy comparison.

To run a Sensitivity Simulation:

- 1) First, enter the lists of values you want used in each of the individual simulations into your cells and formulas using SIMTABLE. For example, possible price levels might be entered into Cell B2:

B2: RiskSimtable({100,200,300,400})

will cause simulation #1 to use a value of 100 for price, simulation #2 to use a value of 200, simulation #3 to use a value of 300 and simulation #4 to use a value of 400.

- 2) Set the number of simulations in the Settings dialog box and run the Sensitivity Simulation using the Start Simulation command.

Each simulation executes the same number of iterations and collects data from the same specified output ranges. Each simulation, however, uses a different value from the SIMTABLE functions in your worksheet.

@RISK processes Sensitivity Simulation data just as it processes data from a single simulation. Each output cell for which data was collected has a distribution for each simulation. Using the functions of @RISK you can compare the results of the different alternatives or "scenarios" described by each individual simulation. The Distribution Summary graph summarizes how the results for an output range change. There is a different summary graph for each output range in each simulation, and these graphs can be compared to show the differences between individual simulations. In addition, the Simulation Summary report is useful for comparing results across multiple simulations.

You also can use Sensitivity Simulation to see how different distribution functions affect your results. The values entered in the SIMTABLE function can be distribution functions. For example, you may wish to see how your results change if you alternately try TRIANG, NORMAL, or LOGNORM as the distribution type in a given cell.

Caution

It is important to distinguish between 1) controlled changes by simulation (which are modeled with the SIMTABLE function) and 2) random variation within a single simulation (which is modeled with distribution functions). SIMTABLE should not be substituted for DISCRETE when evaluating different possible random discrete events. Most modeling situations are a combination of random, uncertain variables and uncertain but "controllable" variables. Typically, the controllable variables will eventually be set to a specific value by the user, based on the comparison conducted with a Sensitivity Simulation.

Advanced Sensitivity Analysis

@RISK 4.5 Professional and Industrial versions include an advanced analysis tool called **Advanced Sensitivity Analysis**. This analysis greatly expands on the sensitivity simulation capabilities described here. For more information on Advanced Sensitivity Analysis, see the Advanced Analyses command in the Reference: @RISK Add-in Menu section of this manual.

Simulating a New Product: The Hippo Example

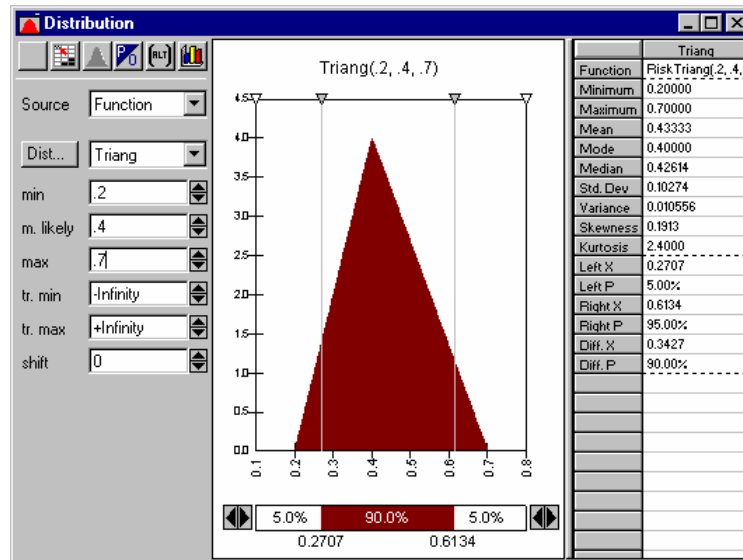
(Chapter 28, Financial Models Using Simulation and Optimization)

When a company develops a new product, the profitability of the product is highly uncertain. Simulation is an excellent tool to estimate the average profitability and riskiness of new products. The following example illustrates how simulation can be used to evaluate a new product.

Example 28.1

ZooCo is thinking of marketing a new drug used to make hippos healthier. At the beginning of the current year there are 1,000,000 hippos that may use the product. Each hippo will use the drug (or a competitor's drug) at most once a year. The number of hippos is forecasted to grow by an average of 5% per year, and we are 95% sure that the number of hippos will grow each year by between 3% and 7%. We are not sure what use of the drug will be during year 1, but our worst case guess is 20% use, most likely use is 40% and best case use is 70%. In later years, we feel the fraction of hippos using our drug (or a competitor's) will remain the same, but in the year after a competitor enters, we lose 20% of our share for each competitor who enters. We will model Year 1 market use with a **triangular random variable**. See Figure 28.1. Basically, @RISK will generate Year 1 market use by making the likelihood of a given market use proportional to the height of the "triangle" in Figure 28.1. Thus a 40% Year 1 market use is most likely; a 30% market use occurs half as often as a Year 1 40% market use, etc. The maximum height of the triangle is 4, because that makes the total area under the triangle equal to one. Probability of market use being in a given range is equal to area in that range under the triangle. For example, the chance of a market use being at most 40% is $.5(4)(.4-.2) = .4$ or 40%.

Figure 28.1



There are three potential entrants (in addition to ZooCo). At the beginning of each year each entrant who has not already entered the market has a 40% chance of entering the market. The year after a competitor enters, our market use drops by 20% for each competitor who entered. Thus if in Year 1 two competitors enter the market, in Year 2 our market use will be reduced by 40%. To model the number of entrants you can use the **binomial random variable** (in @RISK this requires us to use the =RISKBinomial function). The formula

$$= \text{RISKBinomial}(n, p)$$

generates n independent binomial trials (each a success or failure) having probability of success p and keeps track of the number of successes.

We consider a "success" to be a competitor entering the market. Then the formula

$$= \text{RISKBinomial}(2, .4)$$

will simulate the number of entrants during a year in which two competitors have yet to enter the market. Make sure that if all three entrants have entered, no more entrants may enter.

Each unit of the drug is sold for \$2.20 and incurs a variable cost of \$0.40. Profits are discounted by 10% (risk adjusted rate) annually.

Find a 95% CI for risk-adjusted NPV of project. For now we ignore the fixed cost of developing the drug.

Recall that **risk-adjusted** NPV is expected discounted value of cash flows (discounted at risk-adjusted rate).

Solution

Figure 28.2

Our spreadsheet is in Figure 28.2 (file *hippo.xls*).

	A	B	C	D	E	F
1	Pigco					
2	Price	\$ 2.20	Compet %age	0.2		
3	Unit Var Cost	\$ 0.40	Year 1 Market S	1000000		
4	Interest Rate	0.1	Year 1 worst sha	0.2		
5	Entrant Prob	0.4	Year 1 most like	0.4		
6			Year 1 best shar	0.7		
7	Year	1	2	3	4	5
8	Market Size	1000000	1050000	1102500	1157625	1215506.25
9	Use per hippo of our drug	0.433333333	0.346666667	0.277333333	0.277333333	0.277333333
10	Competitors (beginning of year)	0	1	2	2	2
11	Entrants	1	1	0	0	0
12	Unit Sales	433333.3333	364000	305760	321048	337100.4
13	Revenues	\$ 953,333	\$ 800,800	\$ 672,672	\$ 706,306	\$ 741,621
14	Costs	\$ 173,333	\$ 145,600	\$ 122,304	\$ 128,419	\$ 134,840
15	Profits	\$ 780,000	\$ 655,200	\$ 550,368	\$ 577,886	\$ 606,781
16						
17	NPV	\$2,435,545				

Step by Step

Step 1: In row 8 we determine the market size during each of the next five years. In B8 we enter =D3. Assuming year to year growth in market size is normally distributed, the given information tells us that the number of pigs grows from year to year by a percentage which is a normal random variable having mean .05 and standard deviation of .01. This follows because 95% of the time a normal random variable is within 2 standard deviations of its mean. Therefore we may conclude $2\sigma = .02$ or $\sigma = .01$. Thus in C8 we determine the Year 2 Market Size with the formula

$$=B8*RISKNormal(1.05,0.01).$$

Essentially, this formula ensures that each year there is a 68% chance that the size of the hippo market grows by between 4% and 6%, a 95% chance that the hippo market grows by between 3% and 7%, and a 99.7% chance that the hippo market grows by between 2% and 8%. Copying this formula to D8:F8 generates the market size for Years 3-5.

Step 2: In row 9 we determine our market use/hippo for each year. Year 1 market use/hippo is computed in B9 with the formula

$$=RISKTriang(D4,D5,D6).$$

In C9:F9 we account for the fact that the year after entry, each entrant takes away 20% of our market share. Thus in C9 we compute our Year 2 Market use/hippo with the formula

$$=B9*(1-B11*D2).$$

Copying this formula to D9:F9 computes Years 3-5 market share.

Step 3: In Row 11 we determine the number of entrants during each year. If less than 3 competitors have entered, then each competitor who has not yet entered has a 40% chance of entering during the current year. If all three competitors have entered, then nobody can enter. In B11 we compute the number of Year 1 entrants with the formula

$$=If(B10<3, RISKBinomial(3-B10,B5),0).$$

Copying this to C11:F11 computes Years 2-5 entrants. If we do not use the =If statement then in a year after all 3 competitors have entered we will obtain an error message because =RISKBinomial cannot take 0 trials as the first argument.

Step 4: In Row 10 we compute the number of competitors present at the beginning of each Year by adding the number of new entrants to the number of competitors already present. In B10 we enter 0 and in C10 we enter

$$=B10+B11.$$

Copying this formula to D10:F10 computes the number of competitors present at the beginning of each year.

Step 5: In row 12 we compute each year's unit sales = (use/hippo)*market size by copying the formula

$$=B8*B9$$

from B12 to C12:F12.

Step 6: In row 13 we compute our annual revenues by copying the formula

$$=B\$2*B12$$

from B13 to C13:F13.

Step 7: In row 14 we compute our annual variable costs by copying the formula

$$=B\$3*B12$$

from B14 to C14:F14.

Step 8: In row 15 we compute our annual profits by copying the formula

$$=B13-B14$$

from B15 to C15:F15.

Step 9: In B17 we compute the NPV of our 5-year profits with the formula

$$=NPV(B4,B15:F15).$$

Step 10: We now run a simulation with cell B17 (NPV) being our forecast cell. We used 500 trials. Our results follow.

Figure 28.3

Minimum	966350.625
Maximum	4416799
Mean	2312372.866
Standard Deviation	633418.2967
Variance	4.01219E+11
Skewness	0.319535665
Kurtosis	2.669867094
NumErrs	0
Mode	2212183.8
5%	1347058.879
10%	1469903.378
15%	1630650.378
20%	1751069.643
25%	1858571
30%	1933889.883
35%	2012388.996
40%	2096331.542
45%	2181581.218
50%	2265116.5
55%	2332394.792
60%	2432266.516
65%	2535186.715
70%	2636504.196
75%	2765356.75
80%	2877606.315
85%	2985581.684
90%	3165375.941
95%	3399469.707

Our point estimate of risk adjusted NPV is the sample mean of NPV's from simulation (\$2,312372.866). To find a 95% confidence interval for the mean in a simulation use the fact that we are 95% sure actual mean NPV is between

$$(\text{Sample Mean of NPV}) \pm 2 * (\text{Sample Standard deviation}) / \sqrt{n} ,$$

where n = number of iterations.

For example, we are 95% sure the mean NPV (or risk adjusted NPV) is between

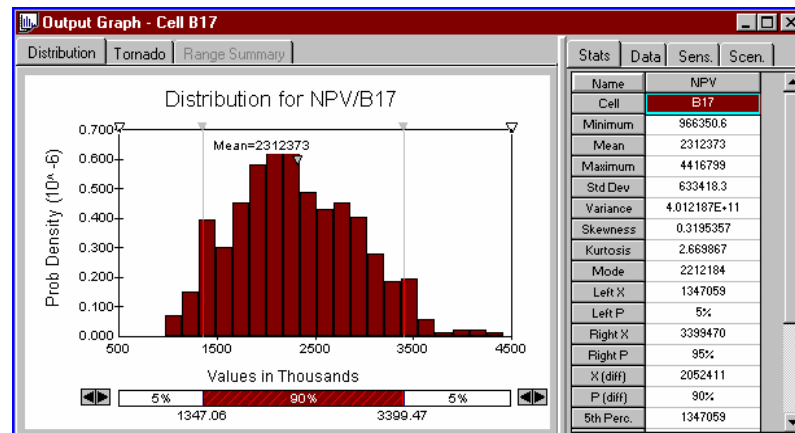
$$2,312373 \pm 2 * (633418) / \sqrt{500} \text{ or}$$

$$\$2,255,718 \text{ and } \$2,369,028.$$

Thus we are pretty sure risk adjusted NPV is between 2.26 and 2.37 million. Since 95% of the time we are accurate within \$50,000 (which is 2% of sample mean) we feel comfortable that we have run enough iterations.

The **actual** discounted (at 10% rate) value of cash flows has much more variability than our confidence interval for risk-adjusted NPV would indicate. To show this look at the following histogram.

Figure 28.4



Note: If you are going to use distribution of NPV's as a tool to compare projects, then you must discount all the company's projects at the same rate (probably obtained from CAPM). Otherwise you will be double counting risk.

Tornado Graphs and Scenarios

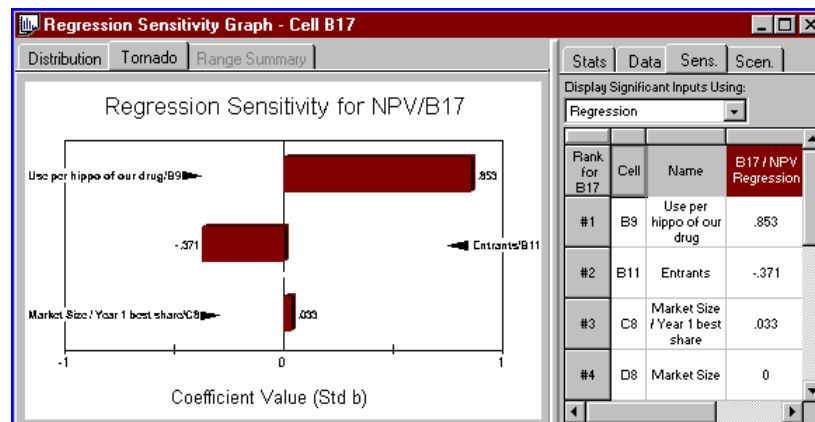
A natural question is what factors have the most influence on the success of the project? Does market growth matter more than the timing of the entrance of competitors? Using @RISK Tornado graphs and Scenario Analysis we can easily answer questions such as:

- What factors appear to have the most influence on the NPV earned by the drug?
- When NPV is in the top 10%ile of all possible NPV, what seems to be going on?

Solution - Part a

Here we utilize a **Tornado Graph**. Make sure that in “*Simulation Settings*” you have checked “*Collect Distribution Samples*”. Then right-click on NPV/B17 in the Explorer list and choose “*Tornado Graph*.” You have two options: A Regression Tornado Graph (see Figure 28.5) or a Correlation Tornado Graph (see Figure 28.6).

Figure 28.5

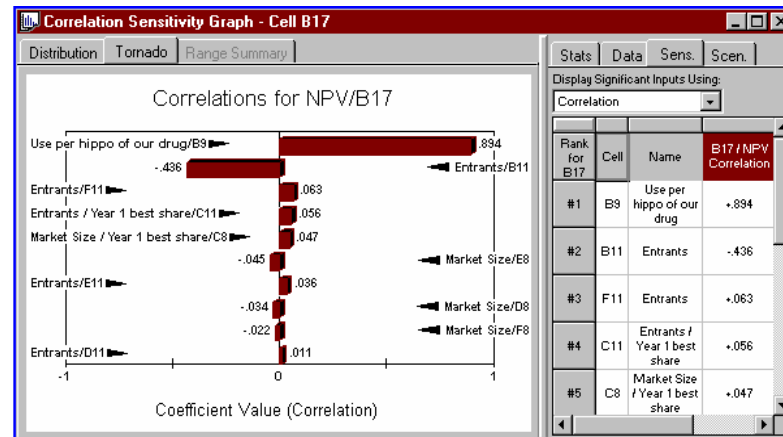


We find (ceteris paribus) from Regression Tornado Graph (obtained by selecting "**Regression**" under the "*Display Significant Inputs Using*" entry on the Sens. Tab on the graph) that

- A one standard deviation increase in Year 1 use increases NPV by .853 standard deviations.
- A one standard deviation increase in number of Year 1 entrants decreases NPV by .371 standard deviations.
- Not much else matters!

Basically, when running a Tornado Graph @RISK runs a regression where each iteration represents an observation. The dependent variable is the output cell (NPV) and the independent variables are each "random" @RISK function in the spreadsheet. Then the .853 coefficient for Year 1 Use is the standardized, or beta weight coefficient of Year 1 Use in this regression.

Figure 28.6



From Tornado Correlation Graph in Figure 28.6 (obtained by a change similar to the one above, except with *Correlation* instead of *Regression*) we find

- Year 1 use is most highly correlated (.89) with NPV
- Next is Year 1 Entrants (-.44)
- Rest of the random cells in the spreadsheet do not matter much!

These correlations are **rank correlations**; for example, for all iterations the values of Year 1 use are ranked, as are values of NPV. Then these **ranks** (not actual values) are correlated.

Solution - Part b

If you check **“Collect Distribution Samples”** under Simulation Settings you can obtain a **Scenario Analysis**. For a given scenario, such as all iterations where NPV is in top 10% of all iterations, the Scenario Analysis identifies random variables whose values differ significantly from their median values.¹

We find from Scenario Approach (see Figure 28.7) (click on the **“Insert New Scenarios Window”** icon or click on **“Insert”** and then **“Scenarios”**) that in the iterations yielding the top 10% of all NPV’s the following variables differ significantly from their overall medians:

- Year 1 Use (median is .596, 1.66 sigma above average)
- Year 2 Entrants (median is 0, 1.53 sigma below average)

To change the scenario settings just click on the **“Scenario=”** row in the Scenario Analysis box. Figure 28.7 contains a listing of three Scenario settings (the top 25%, the bottom 25%, and the top 10% of NPV’s) along with the random variables that differ significantly from their average values when the given scenario occurs. For example, for iterations in which the NPV is in the bottom 25% of all iterations, Year 1 Market Use averaged out to 13.9%.

Figure 28.7

Scenario Analysis:4											
Display Groups of Input Values causing Output Scenarios, using:											
All - %Perc's, Actuals and Ratios											
	Cell	Name	B17 / NPV Actual	B17 / NPV Percentile	B17 / NPV Median/SD	B17 / NPV Actual	B17 / NPV Percentile	B17 / NPV Median/SD	B17 / NPV Actual	B17 / NPV Percentile	B17 / NPV Median/SD
		Scenario=	>75%	>75%	>75%	<25%	<25%	<25%	>90%	>90%	>90%
#1	C8	Market Size / Year 1 best share	..	..	..	..	..	..	..	..	..
#2	D8	Market Size	..	..	..	..	..	..	..	..	..
#3	E8	Market Size	..	..	..	..	..	..	..	..	..
#4	F8	Market Size	..	..	..	..	..	..	..	..	..
#5	B9	Use per hippo of our drug	0.55023	85.2%	+1.211851	0.3170602	13.88287%	-1.056794	0.5964633	92.98451%	+1.661682
#6	B11	Entrants	..	..	..	2	93.6%	+1.177332	..	..	..
#7	C11	Entrants / Year 1 best share	..	..	..	..	..	..	..	..	..
#8	D11	Entrants	0	49.33334%	-1.53486	..	..	..	0	49.33334%	-1.53486
#9	E11	Entrants	..	..	..	..	..	..	1	95.76923%	+1.687376
#10	F11	Entrants	..	..	..	..	..	..	..	..	..

¹ @RISK will identify any random variable whose median value in iterations satisfying the scenario condition differs by more than .5 standard deviations from the median value of the random variable in all iterations.

Finding Value at Risk (VAR) of a Portfolio

(Chapter 45, Financial Models Using Simulation and Optimization)

Anybody who owns a portfolio of investments knows there is a great deal of uncertainty about the future worth of the portfolio. Recently the concept of **value at risk (VAR)** has been used to help describe a portfolio's uncertainty. Simply stated, **value at risk** of a portfolio at a future point in time is usually considered to be the fifth percentile of the loss in the portfolio's value at that point in time. In short, there is considered to be only one chance in 20 that the portfolio's loss will exceed the VAR. To illustrate the idea suppose a portfolio today is worth \$100. We simulate the portfolio's value one year from now and find there is a 5% chance that the portfolio's value will be \$80 or less. Then the portfolio's VAR is \$20 or 20%. The following example shows how @RISK can be used to measure VAR. The example also demonstrates how buying puts can greatly reduce the risk, or **hedge**, a long position in a stock.

Example 45.1

Let's suppose we own one share of Dell computer on June 30, 1998. The current price is \$94. From historical data (see Chapter 41) we have estimated that the growth of the price of Dell stock can be modeled as a Lognormal random variable with $\mu = 57\%$ and $\sigma = 55.7\%$. To hedge the risk involved in owning Dell we are considering buying (for \$5.25) a European put on Dell with exercise price \$80 and expiration date November 22, 1998. Here you will:

- a) Compute the VAR on November 22, 1998 if we own Dell computer and do not buy a put.
- b) Compute the VAR on November 22, 1998 if we own Dell computer and buy the put.

Solution

The key idea is to realize that **in valuing the put we let Dell price grow at the risk-free rate, but when doing a VAR calculation we should let Dell price grow at the rate at which we expect it to grow.** Our work is in file *var.xls*. See Figure 45.1.

Figure 45.1

	A	B	C
2	Stress Testing Dell	Range Name	
3	Current price	S	\$ 94.00
4	Put exercise price	x	\$ 80.00
5	put duration	d	0.39726
6	risk free rate	r	0.053541
7	actual growth rate	g	0.57
8	volatility	v	0.557
9	put price	p	\$ 5.25
10			
11	Dell price at expiration	110.8422852	
12	put value at expiration	0	
13			
14	% age Gain without put	17.9%	
15	%age Gain with put	11.7%	

We have created range names as indicated in Figure 45.1.

Step by Step

Step 1: In cell B11 we generate Dell's price on November 22, 1998 with the formula

$$=S*EXP((g-0.5*v^2)*d+RISKNORMAL(0,1)*v*SQRT(d)).$$

Step 2: In cell B12 we compute the payments from the put at expiration with the formula

$$=If(B11>x,0,x-B11).$$

Step 3: The percentage gain on our portfolio if we just own Dell is given by

$$\frac{\text{Ending DellPrice} - \text{Beginning Dell Price}}{\text{Beginning Dell Price}}.$$

In B14 we compute the percentage gain on our portfolio if we do not buy a put with the formula

$$=(B11-S)/S.$$

Step 4: The percentage gain on our portfolio if we own Dell and a put is

$$\frac{\text{Ending Dell Price} + \text{Cash Flows from Put} - \text{Beginning Dell Price} - \text{Put Price}}{\text{Beginning Dell Price} + \text{Put Price}}$$

In cell B15 we compute the percentage gain on our portfolio if we buy the put with the formula

$$=((B12+B11)-(S+p))/(S+p).$$

Step 5: After selecting B14 and B15 as output cells and running 1600 iterations we obtained the @RISK output in Figure 45.2.

Figure 45.2

	A	B	C	D
5		Outputs	age Gain without put	age Gain with put / p
6		Simulations	1	1
7		Statistics / Cell	\$B\$14	\$B\$15
8		Minimum	-0.642035902	-0.193954661
9		Maximum	3.177449226	2.956475973
10		Mean	0.254243646	0.211036404
11		Standard Deviation	0.454892722	0.403309986
12		Variance	0.206927388	0.162658945
13		Skewness	1.143237318	1.476801364
14		Kurtosis	5.403351991	6.242985756
15		NumErrs	0	0
16		Mode	0.08372049	-0.193954661
17		5%	-0.339069603	-0.193954661
18		10%	-0.248756616	-0.193954661
19		15%	-0.180831468	-0.193954661
20		20%	-0.122562966	-0.168636009
21		25%	-0.069621287	-0.11883527
22		30%	-0.019603747	-0.070426121
23		35%	0.029372538	-0.025077894
24		40%	0.07877676	0.022255717
25		45%	0.12772527	0.068072297
26		50%	0.178600937	0.116256803
27		55%	0.232349445	0.167411774
28		60%	0.288710708	0.221145466
29		65%	0.349292601	0.277919441
30		70%	0.416892367	0.341943413
31		75%	0.493522018	0.414519578
32		80%	0.583930341	0.501486897
33		85%	0.696615509	0.608136356
34		90%	0.847094699	0.74938947
35		95%	1.100368295	0.98926574

We find our VAR if we do not buy the put to be 33.9% of our invested cash while if we buy the put our VAR drops to 19.4% of the invested cash. The reason for this is, of course, that if Dell stock drops below \$80, every one dollar decrease in the value of Dell is countered by a one dollar increase in the value of the put. Also note that if we do not buy the put, Dell (despite its high growth rate) might lose up to 64% of its value.

The following histograms give the distribution of the percentage gain on our portfolio with and without the put.

Figure 45.3

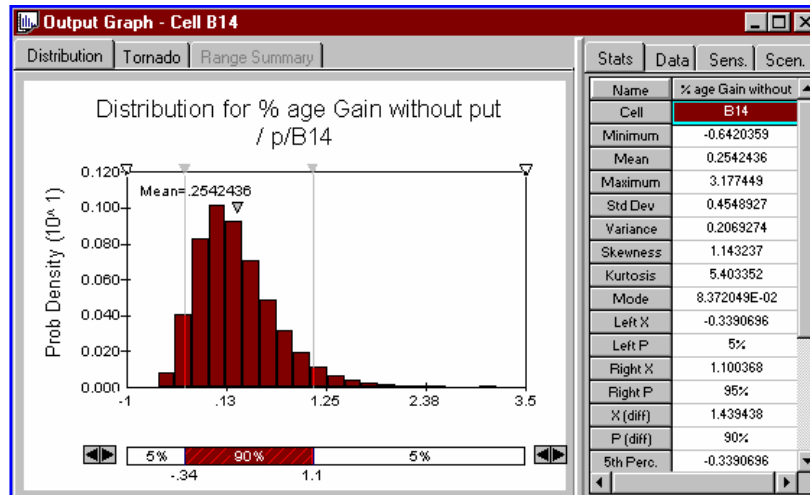
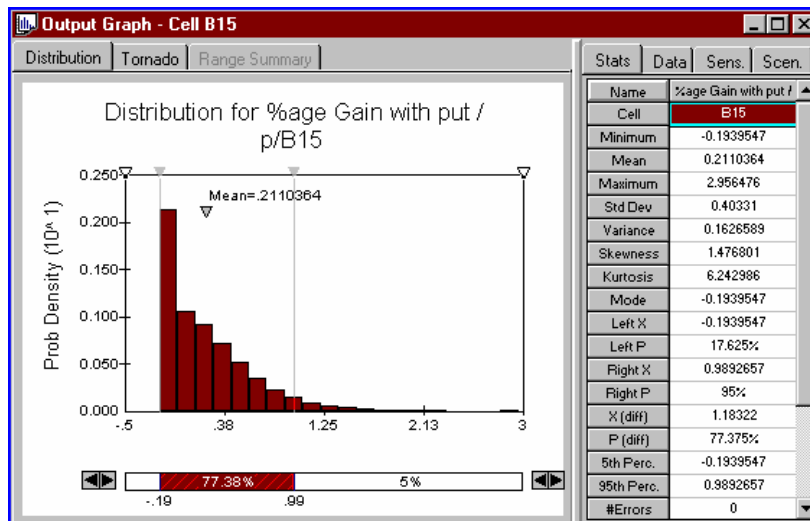


Figure 45.4



From Figures 45.3 and 45.4 we see that there is a much greater chance of a big loss if we do not buy the put. Note, however, that our average return without the put is 25.4% while our average return with the put is 21.1%. In effect, buying the put is a form of **portfolio insurance**, and we must pay for this insurance.

Simulating the NCAA Tournament

(Chapter 62, Financial Models Using Simulation and Optimization)

The file *NCAA.xls* lets you play out the NCAA tournament as many times as you want. We factor in the abilities (through the SAGARIN ratings published in *USA Today*) of each team. Extensive data analysis has indicated that teams play on average to SAGARIN ratings and perform according to a standard deviation of 7 points about that level. For example, in 1997 SAGARIN rated NC a 94 and Fairfield a 70. Thus we would model NC's play by a $RISKNormal(94,7)$ and Fairfield by a $RISKNormal(70,7)$ and declare the team with the higher performance the winner. Our simulation of the 1996 NCAA tournament is in file *NCAA96.xls*

To begin we label the EAST teams 1-16 in the order they are listed in bracket. Then teams 17-32 are the SOUTHEAST, teams 33-48 the WEST and teams 49-64 the MIDWEST. It is important that we list things so that winner of 1 and 2 plays winner of 3 and 4, etc.

Step by Step

Step 1: We enter the ratings, numerical codes, and team names in rows 2-4. We name the range A3:BL4 Ratings.

	A	B	C	D
1	1	2	3	4
2	UNC	Fairfield	Ind	Col
3	1	2	3	4
4	94.4	70.3	85.3	82

	A	B	C
5	East		
6	1		2
7	94.4	1	70.3

Step 2: We model the UNC Fairfield game in A6:C7. In A7 we generate UNC's performance with the formula

$=RISKNormal(HLOOKUP(A6,Ratings,2),7)$.

This looks up UNC's rating and generates a performance with that mean and a standard deviation of 7.

Similarly, in C7 we generate Fairfield's performance. In B7 we determine who wins the game with the formula

`=If(A7>C7,A6,C6).`

After "playing" the Colorado-Indiana game in E6:G7 (see Figure 62.1) we play the winners of these two games in A9:C10.

Figure 62.1

	E	F	G
6	3		4
7	85.3	3	82

We ensure that the entry in A9 is the winner of UNC-Fairfield Game and the entry in C9 is winner of Indiana-Colorado game. Then in Row 10 we "play" this game. See Figure 62.2.

Figure 62.2

	A	B	C
9	1		3
10	94.4	1	85.3

You can follow this logic down to Row 57. Here the Final Four begins! See Figure 62.3.

Figure 62.3

	A	B	C	D	E	F	G	H
57		East		West		Midwest		Mideast
58		1		17		33		49
59		94.4	17	97.9		97.4	33	93.6
60								
61								
62	Finals							
63		17		33				
64		97.9	17	97.4				
65			Kansas					

In 1997 East played West and Midwest played Mideast. Each year the final four matchups will change and you will need to adjust this part of spreadsheet. In C65 we print out the winner with the formula

`=HLOOKUP(C64,A1:BL2,2).`

This formula finds the Team Name corresponding to the code number of the winner. Hit the F9 key several times to see what happens.

We used cell C64 as our output cell and ran the tournament 5000 times. The teams having at least a 5% chance of winning were

- UNC: 13%
- Kansas: 26%
- Kentucky: 27%
- Duke: 8%
- Minnesota: 9%

Of course, Arizona won (we gave them a .0084 chance!). That's what makes sports great!

Remarks

Remember each year the Final Four brackets change. This will require you to rearrange the rows where the East, Midwest, Mideast and West regions are located.

Chapter 6: Distribution Fitting

Overview	129
Define Input Data	131
Sample Data	131
Density Data	132
Cumulative Data	132
Filtering Your Data	133
Bringing Data Into @RISK For Fitting	133
Select Distributions To Fit	135
Continuous vs. Discrete Distributions.....	135
Estimated Parameters vs. Predefined Distributions.....	135
Domain Limits.....	136
Run The Fit	139
Sample Data – Maximum Likelihood Estimators (MLEs)	139
Curve Data – The Method of Least Squares.....	141
Interpret the Results	143
Ranking of Fits	143
Graphs	143
Statistics and Targets.....	146
Fit Statistics	146
P-Values and Critical Values	149
Using the Results of a Fit.....	151
Exporting Graphs and Reports	151
Specifying Distributions in Excel.....	152

Overview

@RISK allows you to fit probability distributions to your data (Professional and Industrial versions only). Fitting is done when you have a set of collected data that you want to use as the basis for an input distribution in your spreadsheet. For example, you may have collected historical data on a product price and you might want to create a distribution of possible future prices that is based on this data.

Fitting is done using an integrated copy of **BestFit**, Palisade Corporation's distribution fitting software package. This program may also be run without @RISK. BestFit running without @RISK looks very similar to the @RISK – Model window, except that there is no Model tab.

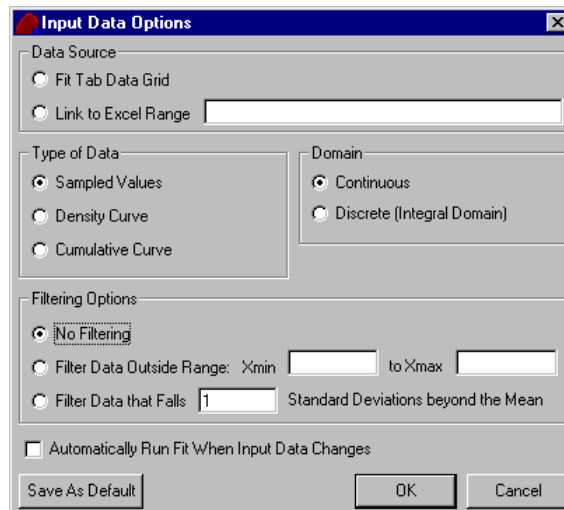
To fit distributions to data using @RISK, there are five steps that you should consider:

1. **Define Input Data**
2. **Specify Distributions to Fit**
3. **Run the Fit**
4. **Interpret the Results**
5. **Using the Results of a Fit**

Each of these steps is discussed in this chapter.

Define Input Data

@RISK allows you to analyze three kinds of data for distribution fitting: sample, density and cumulative. @RISK supports up to 100,000 data points for each of these types. The available data types are shown in the Input Data Options dialog box in the Model window.



Sample Data

Sample (or observation) data is a set of values drawn randomly from a large population. Distributions are fit to sample data to estimate the properties of that population.

Continuous vs. Discrete Samples

Sample data is either continuous or discrete. Continuous sample data can take on any value over a continuous range, while discrete data is limited to integer values. Discrete data can be entered in two formats. In the “standard” format, you enter each data point individually. In the “counted” format, the data is entered in pairs, where the first value is the sampled value and the second is the number of samples drawn with that value.

Data Requirements

Data requirements for sample data include:

- ◆ You must have at least five data values.
- ◆ Discrete data values must be integral.
- ◆ All sample values should fall in the range $-1E+37 \leq x \leq +1E+37$.

Density Data

Density data is a set of (x,y) points that describe the probability density function of a continuous distribution. Distributions are fit to density data to give the best representation of the curve points using a theoretical probability distribution.

Normalization of Density Data

Since all probability distribution functions must have unit area, @RISK automatically will scale your y-values so that the density curve described by your data has an area of one. Since the points you specify are isolated points on a continuum, linear interpolation between these points is used to calculate the normalization factor. In certain cases, such as fitting to data generated from a mathematical function already known to be normalized, it is undesirable to have @RISK apply its own normalization. In these cases, you may turn off this feature.

Data Requirements

Data requirements for density data include:

- ◆ You must have at least three (x,y) data pairs.
- ◆ All x-values must be in the range $-1E+37 \leq x \leq +1E+37$.
- ◆ All x-values should be distinct.
- ◆ All y-values must be in the range $0 \leq y \leq +1E+37$.
- ◆ At least one y-value must be non-zero.

Cumulative Data

Cumulative data is a set of (x,p) points that describe a continuous cumulative distribution function. The p-value associated with a given x-value is the probability of obtaining a value less than or equal to x. Distributions are fit to cumulative data to give the best representation of the curve points using a theoretical probability distribution.

Endpoint Interpolation

In order to calculate statistics and display graphs of your cumulative data, @RISK needs to know where the input minimum and maximum are (that is, the points with p=0 and p=1). If you do not explicitly supply these points, @RISK will linearly interpolate them from your data. In general, it is recommended that you always include the p=0 and p=1 points in your data set, if possible.

Data Requirements

Data requirements for cumulative data include:

- ◆ You must have at least three (x,p) data pairs.
- ◆ All x-values must be in the range $-1E+37 \leq x \leq +1E+37$.
- ◆ All x-values must be distinct.
- ◆ All p-values must be in the range $0 \leq p \leq 1$.
- ◆ Increasing x-values must always correspond to increasing p-values.

Filtering Your Data

You can further refine your input data by applying an input filter. Filtering tells @RISK to ignore outliers, based on criteria you specify, without requiring you to explicitly remove them from your data set. For example, you may wish to only analyze x-values greater than zero. Or, you may wish to filter values that lie outside two standard deviations from the mean.

Bringing Data Into @RISK For Fitting

Numerous methods are available for bringing your data into @RISK. You may type it directly into the input data grid, paste it from another Windows application, fit directly from the @RISK-Results window, or even create a link between @RISK and an Excel spreadsheet.

The **Paste** command imports data to the input sheet from the Windows Clipboard. To do so, highlight the data you want to copy and paste into your @RISK input sheet. To import data from a non-spreadsheet application, be sure that paired data is tab-delimited and each set ends with a carriage return.

Data that resulted from an @RISK simulation can be fit very easily by choosing the **Fit** command from the Explorer list pop-up menu in the @RISK-Results window.

You can also link the data on a fit tab to a range in Microsoft Excel. To do this, highlight the range you want to link, and click the **Fit Distributions to Data** command from within Excel. Alternatively, you can set the link directly in the **Input Data Options** dialog in the @RISK-Model window.

Select Distributions To Fit

After you define your data set, you must specify the distributions you want @RISK to attempt to fit. There are three general questions you must answer to do this.

Continuous vs. Discrete Distributions

For sample data, you should first decide if your data is continuous or discrete. Discrete distributions always return integer values. For example, presume you have a set of data describing the number of failures in a series of 100 trial batches. You would only want to fit discrete distributions to this set because partial failures are not allowed. In contrast, continuous data can take on any value in a range. For example, presume you have a set of data describing the height, in inches, of 300 people. You would want to fit continuous distributions to this data, since heights are not restricted to integral values.

If you specify that your data is discrete, all your data values must be integers. Keep in mind, however, that the converse is not true. Just because you have all integral data values does not mean you have to fit only discrete distributions. In the previous example, the height data set may be rounded to the nearest inch, but fitting to continuous distributions is still appropriate.

@RISK does not support the fitting of discrete distributions to density and cumulative curve data.

You can specify whether your data set is continuous or discrete in the **Input Data Options** dialog.

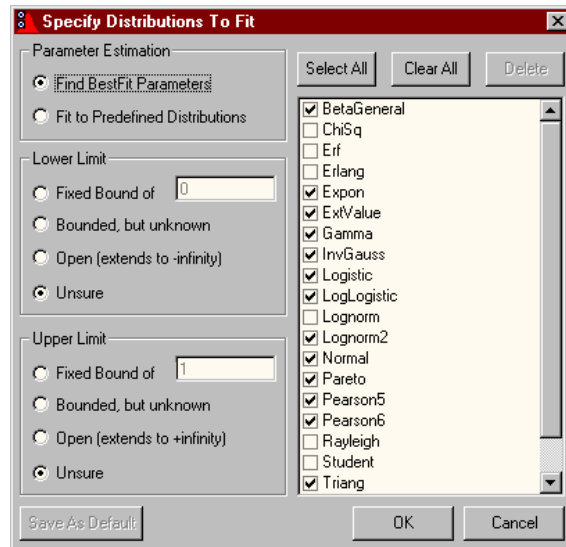
Estimated Parameters vs. Predefined Distributions

Generally, you will want @RISK to estimate the parameters of your distributions. However, in some cases, you may want to specify exactly what distributions to use. For example you may want to have @RISK compare two competing hypotheses and tell you which one is a better description of your data.

Predefined distributions can be set in the **Specify Distributions to Fit** dialog.

Domain Limits

For continuous data sets (sample or curve data) you can specify how you want @RISK to treat the upper and lower limits of the distributions. For both limits there are four choices: fixed bound, unknown bound, open bound, and unsure. Domain limits can be set in the **Specify Distributions to Fit** dialog.



Fixed Bound

If you specify a fixed bound, you are telling @RISK that the limit of the distribution must be the value you specify. For example, if you have a data set of the times between arrivals of customers in a queue, you might want to fit distributions which have a fixed lower bound of zero, since it is impossible to have a negative time between events.

Unknown Bound

If you specify an unknown bound, you are telling @RISK that the limit of the distribution has a finite bound (that is, it does not extend to plus or minus infinity). Unlike a fixed bound, however, you do not know what the actual value of the limit is. You want @RISK to choose the value for you as it performs its fit.

Open Bound

If you specify an open bound, you are telling @RISK that the limit of the distribution must extend to minus infinity (for a lower bound) or plus infinity (for an upper bound).

Unsure

This is the default option. It is the combination of an unknown bound and an open bound. The limits of distributions that are non-asymptotic are treated as in the unknown bound case, while asymptotic distributions are still included as in the open bound case.

Note, not all distributions functions are compatible with all the possible choices. For example, you can not specify a fixed or unknown lower bound for the Normal distribution, since it asymptotically extends to minus infinity.

Run The Fit

To start the fitting process, click the **Run Fit** icon on the Fitting toolbar.

For each of the distributions specified in the previous step, @RISK will try to find the set of parameters that make the closest match between the distribution function and your data set. Keep in mind, @RISK does not produce an absolute answer, but rather identifies a distribution that *most likely* produced your data. Always evaluate your @RISK results quantitatively and qualitatively, examining both the comparison graphs and statistics before using a result.

@RISK uses two methods to calculate the best distributions for your data set. For sample data, distribution parameters are estimated using Maximum Likelihood Estimators (MLEs). For density and cumulative data (collectively known as curve data), the method of least squares is used to minimize the root-mean square error between the curve points and the theoretical function.

Sample Data – Maximum Likelihood Estimators (MLEs)

The MLEs of a distribution are the parameters of that function that maximize the probability of obtaining the given data set.

Definition

For any density distribution $f(x)$ with one parameter α , and a corresponding set of n sampled values X_i , an expression called the likelihood may be defined:

$$L = \prod_{i=1}^n f(X_i, \alpha)$$

To find the MLE, simply maximize L with respect to α :

$$\frac{dL}{d\alpha} = 0$$

and solve for α . The method described above can be easily generalized to distributions with more than one parameter.

A Simple Example

An exponential function with a fixed lower bound of zero has only one adjustable parameter, and its MLE is easily calculated. The distribution's density function is:

$$f(x) = \frac{1}{\beta} e^{-x/\beta}$$

and the likelihood function is:

$$L(\beta) = \prod_{i=1}^n \frac{1}{\beta} e^{-X_i/\beta} = \beta^{-n} \exp\left(-\frac{1}{\beta} \sum_{i=1}^n X_i\right)$$

To simplify matters, we can use the natural log of the likelihood function:

$$l(\beta) = \ln L(\beta) = -n \ln(\beta) - \frac{1}{\beta} \sum_{i=1}^n X_i$$

To maximize the log of the likelihood, simply set its derivative with respect to β to zero:

$$\frac{dl}{d\beta} = \frac{-n}{\beta} + \frac{1}{\beta^2} \sum_{i=1}^n X_i$$

which equals zero when:

$$\beta = \sum_{i=1}^n \frac{X_i}{n}$$

Therefore, when @RISK tries to fit your data to the best Exponential function with a fixed lower bound of zero, it first finds the mean of the input data and uses it as the MLE for β .

Modifications to the MLE Method

For some distributions, the MLE method described above does not work. For example, a 3-parameter Gamma distribution (a Gamma distribution whose lower bound is allowed to vary) can not always be fit using MLEs. In these cases @RISK will resort to a hybrid algorithm, which combines the standard MLE approach with a moment matching procedure.

In certain distributions, a strict MLE method produces parameters which are heavily biased for small sample sizes. For example, the MLE of the “shift” parameter of an exponential distribution and the minimum and maximum parameters of the uniform distribution are heavily biased for small sample sizes. Where possible, @RISK will correct for the bias.

Curve Data – The Method of Least Squares

The root-mean square error (RMSErr) between set of n curve points (Xi, Yi) and a theoretical distribution function $f(x)$ with one parameter α is:

$$RMSErr = \sqrt{\frac{1}{n} \sum_{i=1}^n (f(x_i, \alpha) - y_i)^2}$$

The value of α that minimizes this value is called the least squares fit. In a sense, this value minimizes the “distance” between the theoretical curve and the data. The formula above is easily generalized to more than one parameter.

This method is used to calculate the best distribution for both density and cumulative curve data.

Interpret the Results

Once @RISK has completed the fitting process, you should review its results. @RISK provides a powerful array of graphs, statistics, and reports to help you evaluate fits and select the best choice for your models.

Ranking of Fits

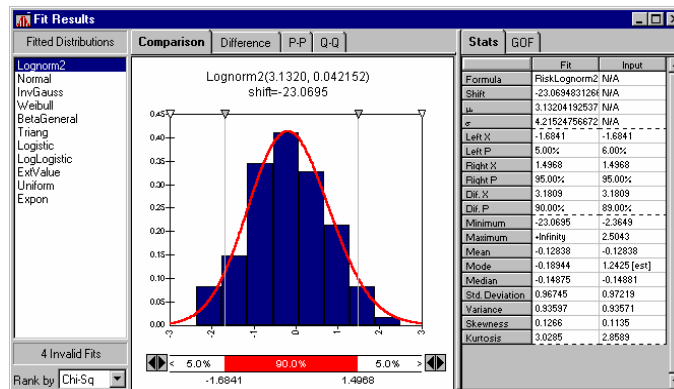
@RISK ranks all the fitted distributions using one or more fit statistics. For continuous sample data, you can choose to rank fits by their chi-squared statistic, Anderson-Darling statistic, or Kolmogorov-Smirnov statistic. Each of these statistics is discussed in more detail, later in this section. For discrete sample data, only the chi-squared statistic can be used. For density and cumulative curve data, the fits are ranked by their RMS Error value.

Graphs

@RISK provides four types of graphs to help you visually assess the quality of your fits.

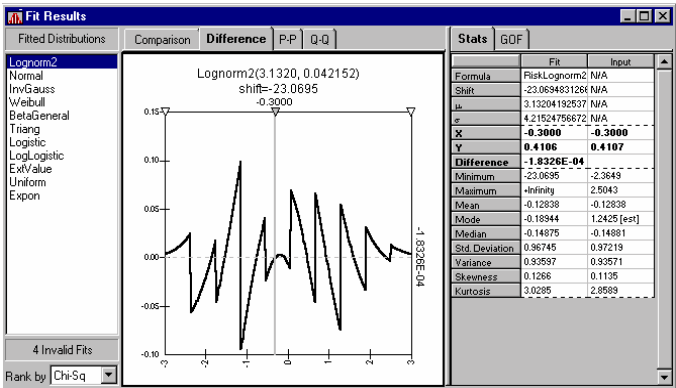
Comparison Graphs

A comparison graph superimposes the input data and fitted distribution on the same graph, allowing you to visually compare them either as density or cumulative curves. This graph allows you to determine if the fitted distribution matches the input data in specific areas. For example, it may be important to have a good match around the mean or in the tails.



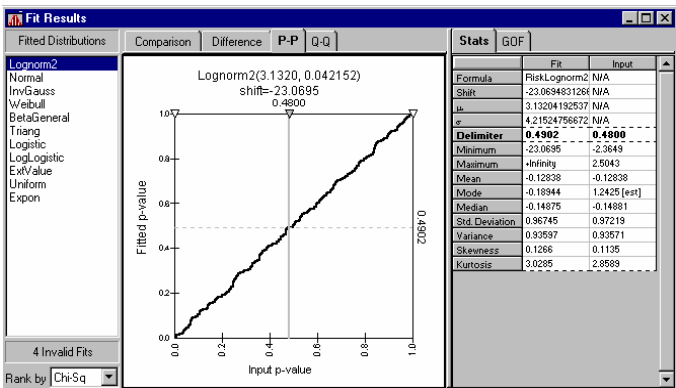
Difference
Graphs

A difference graph displays the absolute error between the fitted distribution and the input data.



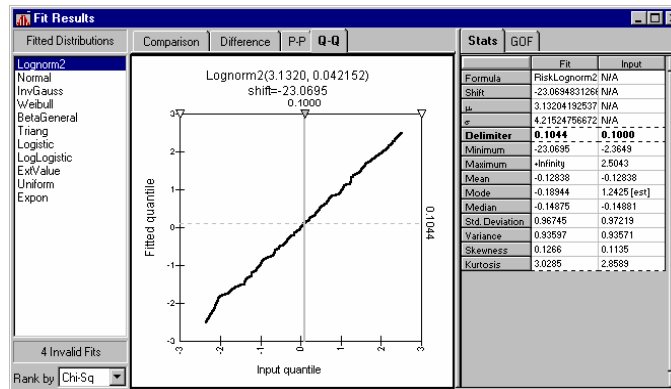
P-P Graphs

Probability-Probability (P-P) graphs plot the distribution of the input data (P_i) vs. the distribution of the result ($F(x_i)$). If the fit is "good," the plot will be nearly linear. P-P graphs are only available for fits to sample data.



Q-Q Graphs

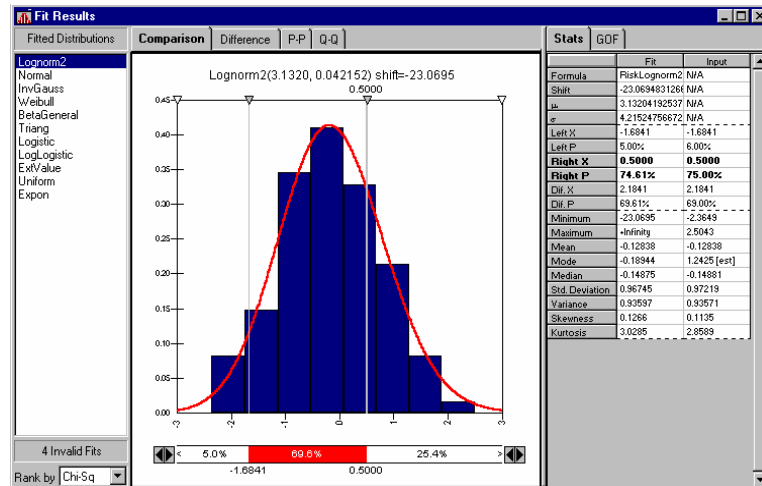
Quantile-Quantile (Q-Q) graphs plots percentile values of the input distribution (x_i) vs. percentile values of the result ($F^{-1}(P_i)$). If the fit is "good," the plot will be nearly linear. Q-Q graphs are only available for fits to continuous sample data.



Statistics and Targets

@RISK reports basic statistics (mean, variance, mode, etc.) for each fitted distribution, which can easily be compared to the same statistics for the input data.

@RISK allows you to compare percentiles and target values between distributions and the input data. For example, perhaps the 5th and 95th percentiles values are important to you. This can be done in two ways. First, all @RISK graphs have a set of “delimiters” which allow you to visually set two different targets or percentiles. Second, the @RISK Summary Report has a data entry area for specifying up to ten different targets or percentiles.



Fit Statistics

For each fit, @RISK reports one or more fit statistics. These statistics measure how good the distribution fits the input data and how confident you can be that the data was produced by the distribution function. For each of these statistics, the smaller the value, the better the fit. @RISK makes use of four different fit statistics: chi-squared, Kolmogorov-Smirnov, Anderson-Darling, and Root-Mean Squared Error.

When more than one fit statistic is available, there is no hard rule to decide which test will give you the "best" result. Each test has its strengths and weaknesses. You must decide which information is most important to you when considering which test to use.

Chi-Squared Statistic

The chi-squared statistic is the best known goodness-of-fit statistic. It can be used with both continuous and discrete sample data. To calculate the chi-squared statistic, you first must break up the x-axis domain into several “bins”. The chi-squared statistic is then defined as:

$$\chi^2 = \sum_{i=1}^K \frac{(N_i - E_i)^2}{E_i}$$

where

K = the number of bins

N_i = the observed number of samples in the i^{th} bin

E_i = the expected number of samples in the i^{th} bin.

A weakness of the chi-squared statistic is that there are no clear guidelines for selecting the number and location of the bins. In some situations, you can reach different conclusions from the same data depending on how you specified the bins.

Some of the arbitrariness of the bin selection can be removed by telling @RISK to use equiprobable bins. In this mode, @RISK will adjust the bin sizes based on the fitted distribution, trying to make each bin contain an equal amount of probability. For continuous distributions this is straightforward. For discrete distributions, however, @RISK will only be able to make the bins approximately equal.

@RISK allows you full control of how bins are defined for the chi-squared test. These settings are in the **Define Chi-Squared Binning** dialog.

Kolmogorov- Smirnov Statistic (K-S)

Another fit statistic that can be used for continuous sample data is the Kolmogorov-Smirnov statistic, which is defined as

$$D_n = \sup \left[\left| F_n(x) - \hat{F}(x) \right| \right]$$

where

n = total number of data points

$\hat{F}(x)$ = the fitted cumulative distribution function

$$F_n(x) = \frac{N_x}{n}$$

N_x = the number of X_i 's less than x .

The K-S statistic does not require binning, which makes it less arbitrary than the chi-squared statistic. A weakness of the K-S statistic is that it does not detect tail discrepancies very well.

Anderson-Darling Statistic (A-D)

The final fit statistic that can be used with continuous sample data is the Anderson-Darling Statistic, which is defined as:

$$A_n^2 = n \int_{-\infty}^{+\infty} [F_n(x) - \hat{F}(x)]^2 \Psi(x) \hat{f}(x) dx$$

where

n = total number of data points

$$\psi^2 = \frac{1}{\hat{F}(x)[1 - \hat{F}(x)]}$$

$\hat{f}(x)$ = the hypothesized density function

$\hat{F}(x)$ = the hypothesized cumulative distribution function

$$F_n(x) = \frac{N_x}{n}$$

N_x = the number of X_i 's less than x .

Like the K-S statistic, the A-D statistic does not require binning. But unlike the K-S statistic, which focuses in the middle of the distribution, the A-D statistic highlights differences between the tails of the fitted distribution and input data.

Root-Mean Squared Error (RMSErr)

For density and cumulative curve data, the only fit statistic used is the Root-Mean Squared Error. This is the same quantity that @RISK minimized to determine the distribution parameters during its fitting process. It is a measure of the “average” squared error between the input and fitted curve.

P-Values and Critical Values

The goodness-of-fit statistic reports a measure of the deviation of the fitted distribution from the input data. As mentioned earlier, the smaller the fit statistic is, the better the fit. But how small a value is needed for a “good” fit? For fits to sample data, this section explains how P-values and critical values can be used to analyze the “goodness” of a fit.

For the discussion below, suppose we have a distribution fitted to a set of N sampled values, and a corresponding fit statistic, s .

P-Values

How likely is it that a new set N samples drawn from the fitted distribution would generate a fit statistic greater than or equal to s ? This probability is referred to as the P-value and is sometimes called the “observed significance level” of the test. As the P-value decreases to zero, we are less and less confident that the fitted distribution could possibly have generated our original data set. Conversely, as the P-value approaches one, we have no basis to reject the hypothesis that the fitted distribution actually generated our data set.

Critical Values

Often we want to turn the same question around and specify a particular level of significance to use, usually denoted by α . This value is the probability that we will incorrectly reject a distribution because it generated, due to statistical fluctuations, a value of s that was very large. Now we want to know, given this significance level, what the largest value of s is that we would accept as a valid fit. This value of s is called the “critical value” of the fit statistic at the α level of significance. Any fit that has a value of s above the critical value is rejected, while fits with values of s below the critical value are accepted. Typically, critical values depend on the type of distribution fit, the particular fit statistic being used, the number of data points, and the significance level.

Calculation Methods in @RISK

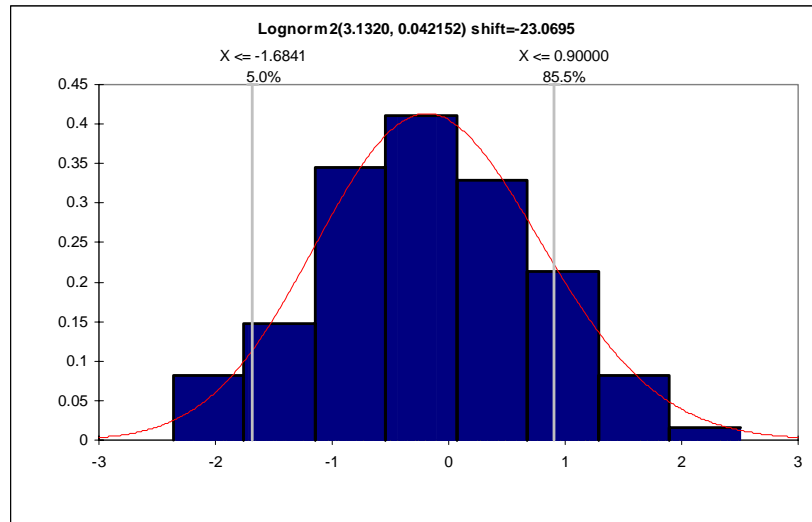
For the chi-squared test, the P-values and critical values can be calculated by finding the appropriate points on a chi-square distribution with $k-1$ degrees of freedom (where k is the number of bins). While this method is exactly correct when predefined distributions are used, it turns out to be only an approximation for distributions where @RISK estimated one or more distribution parameters. Conveniently, however, the approximation is always a conservative one. That is, the reported values for both your critical values and P-value will be slightly higher than the exact values. More information about this can be found in *Appendix D: Recommended Readings* in this manual.

Most critical values and P-values for the A-D and K-S fit statistics have been found by very detailed Monte-Carlo studies (see *Appendix D: Recommended Readings* for references). Unfortunately, not all distributions have been analyzed in enough detail for @RISK to be able to report them. Where possible @RISK will report the appropriate P-values and critical values. Often, where an exact P-value calculation is not possible, a range is returned for the P-value, indicating that the true P-value lies between the specified upper and lower limit.

Using the Results of a Fit

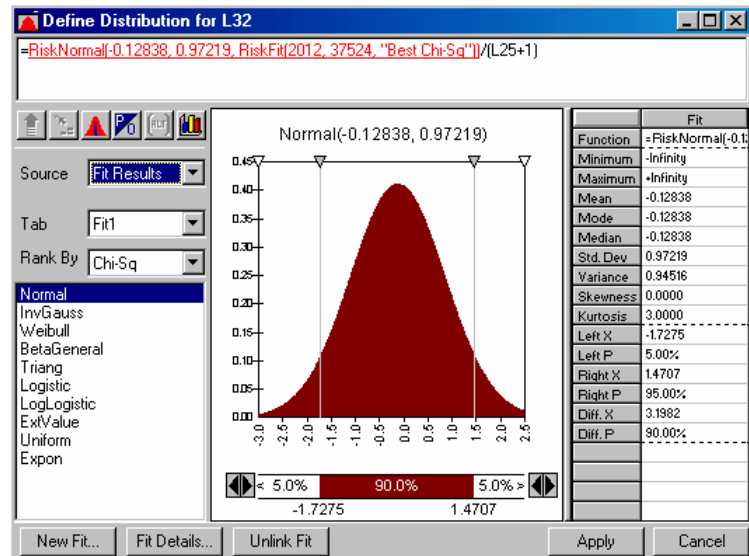
Exporting Graphs and Reports

Once you have analyzed the results of your calculation, you may wish to export the results to another program. Of course, you can always copy and paste any @RISK graph or report into Excel or another Windows application via the clipboard. In addition, using the **Graph In Excel** command, @RISK allows you to create a copy of the current @RISK graph in Excel's native chart format.



Specifying Distributions in Excel

Often you will want to use the result of a fit in an @RISK model. If you are using @RISK Professional or Industrial with the built-in fitting capabilities of BestFit, this is easy. In the **Define Distribution** window, simply change the source list box to say “Fit Result” and select your distribution.



A quick method for using a fit to define a distribution in an @RISK model using data that resides in an Excel spreadsheet is to click the **New Fit** button from the **Define Distribution** window. Just pop-up the Define Distribution window when selecting the cell with the uncertain value. Then, click New Fit and select the data in Excel to fit. Your fit will automatically run and return the fit results to the window. Then you can select your distribution from the Fit Results.

Chapter 7: @RISK Reference Guide

Introduction	161
Reference: @RISK Icons	163
@RISK Add-in Toolbar	163
@RISK Model Window Toolbar	166
@RISK Results Window Toolbar	169
DecisionTools Toolbar	172
Reference: @RISK Add-In Menu Commands	173
File Menu	175
New Command	175
Open Command	175
Save Command, Save As Command	176
Exit Command	176
Model Menu	177
Define Distribution Command	177
Add Output Command	184
Select @RISK Functions Command	185
Fit Distributions to Data Command	186
List Outputs and Inputs Command	187
How is the Outputs and Inputs List Created?	188
Show Model Window Command	188
Simulate Menu	189
Simulation Settings Command	189
Iterations Tab – Simulation Settings Command	190
Sampling Tab – Simulation Settings Command	194
Macro Tab – Simulation Settings Command	197
Monitor Tab – Simulation Settings Command	199
Start Simulation Command	202
Results Menu	203
Report Settings Command	203
Show Results Window Command	205

Options Menu	207
Show Expanded Toolbar Command.....	207
Display Cumulative Descending Percentiles Command	207
Advanced Analyses Menu	209
Goal Seek Command.....	211
Options Dialog – Goal Seek Command.....	213
Analyze – Goal Seek Command.....	215
Stress Analysis Command.....	217
Options – Stress Analysis Command	221
Analyze – Stress Analysis Command.....	223
Advanced Sensitivity Analysis Command.....	229
Input Definition - Advanced Sensitivity Analysis Command ...	231
Step Type - Advanced Sensitivity Analysis Command.....	234
Options - Advanced Sensitivity Analysis Command.....	237
Analyze - Advanced Sensitivity Analysis Command	239
 Reference: @RISK Model Window Commands	 245
File Menu.....	247
New Command	247
Open Command	247
Save Command, Save As Command.....	247
Print Command.....	247
Exit Command.....	248
Edit Menu	249
Cut Command.....	249
Copy Command.....	249
Paste Command	249
Clear Command.....	249
Delete Tab Command.....	250
Rename Tab Command.....	250
View Menu	251
Insert Menu	253
Fit Tab Command.....	253
Artist Window Command.....	254
Correlation Window Command	258
Distribution Window Command	257
Inputs and Outputs Window Command	259
Fit Results Window Command.....	254
Fit Summary Window Command	255
Simulation Menu.....	261

Settings Command.....	261
Start Command.....	261
Model Menu	263
Define Distribution Command	263
Function Properties Command.....	264
Remove Functions Command.....	265
Correlate Distributions Command	266
Entering Correlation Coefficients.....	268
Understanding Rank Order Correlation Coefficient Values	270
Delete Correlation Matrix Command.....	271
Find Outputs and Inputs Command	271
Correlation Menu	273
Check Matrix Consistency Command.....	273
Insert Row/Column Command.....	274
Delete Selected Row/Column(s) Command.....	274
Detach Selected Input(s) Command	274
Instance Commands	275
Create New Instance Command	276
Delete Instance Command	277
Rename Instance Command	277
Correlation Window Options	278
Fitting Menu.....	281
Run Fit Command.....	281
Fit Results Window	282
Fit Results – Graphs.....	285
Fit Results – Statistics and Goodness of Fit	288
Fit Results – Fit Summary Window	291
Specify Distributions to Fit Command.....	293
Define Chi-Sq Binning Command	296
Input Data Options Command.....	299
Sort Data Command	302
Generate Data Command	302
Transform Data Command.....	304
Update Linked @RISK Functions Command	305
Graph Menu	307
Format Graph Command	307
Type Tab – Graph Format Command.....	307
Scaling Tab – Graph Format Command.....	309
Style Tab – Graph Format Command.....	311
Titles Tab – Format Command	312
Delimiters Tab – Graph Format Command.....	313
Graph in Excel Command.....	314

Delimiter Defaults Command	314
Artist Menu.....	315
Clear Curve Command.....	316
Smooth Curve Command	316
Copy Command.....	316
Create Distribution Command	317
Fit Curve Command.....	318
Window Menu	321
Show Excel Window Command	321
Show Results Window Command	321
Cascade Command, Tile Command.....	321
List of Available Windows.....	321
Help Menu	323
How Do I?	323
@RISK Help, Distributions Help	323
Online Manual.....	323
Authorization Command	323
About Command	324
Reference: @RISK Results Window Commands	325
File Menu.....	327
New Command	327
Open Command	327
Save Command, Save As Command.....	327
Print Command.....	327
Exit Command.....	328
Edit Menu	329
Copy Command.....	329
Paste Command	329
Fill Down Command	329
Fill Right Command	330
Move or Copy Window Command	330
Delete Tab Command.....	331
Rename Tab Command.....	331
View Menu	333
Insert Menu	335
Tab Command.....	335
Graph Command.....	335
Histogram and Cumulative Graphs.....	336

Tornado Graphs.....	337
Summary Graphs	338
Overlay Graphs	340
Summary Statistics Command.....	341
Detailed Statistics Command	342
Data Command.....	344
Sensitivities Command.....	345
Multivariate Stepwise Regression	345
Rank Order Correlation	346
Comparison of Methods	347
Scenarios Command	348
What is Scenario Analysis?	348
Interpreting the Results	349
Simulation Menu	351
Settings Command.....	351
Start Command.....	351
Results Menu	353
Real-Time Results Command.....	353
Convergence Monitoring Command.....	354
Filter Command.....	355
Fit Command.....	357
Report Settings Command	357
Quick Report Command.....	358
Graph Menu	359
Format Graph Command	359
Type Tab – Graph Format Command.....	359
Scaling Tab – Graph Format Command.....	363
Style Tab – Graph Format Command.....	366
Titles Tab – Format Command	368
Delimiters Tab – Graph Format Command.....	370
Variables To Graph Tab – Graph Format Command	371
Graph Type Command	374
Graph in Excel Command.....	375
Delimiter Defaults Command	375
Window Menu.....	377
Show Excel Window Command	377
Show Model Window Command.....	377
Cascade Command, Tile Command	377
List of Available Windows.....	377
Help Menu.....	379
How Do I?	379
@RISK Help, Distributions Help	379

Online Manual.....	379
Authorization Command	379
About Command	380
 Reference: @RISK Functions	 381
Introduction	381
Distribution Functions	381
Simulation Output Functions	388
Simulation Statistics Functions	389
Graphing Function.....	389
Supplemental Functions	389
Limiting Workbooks and Worksheets Searched for @RISK Functions	390
Table of Available Functions	391
 Reference: Distribution Functions	 399
RiskBeta	399
RiskBetaGeneral.....	399
RiskBetaGeneralAlt.....	400
RiskBetaSubj.....	400
RiskBinomial	401
RiskChiSq.....	401
RiskCumul.....	402
RiskCumulD	403
RiskDiscrete	404
RiskDUniform	404
RiskErf.....	405
RiskErlang	405
RiskExpon.....	405
RiskExponAlt.....	406
RiskExtValue.....	406
RiskExtValueAlt.....	406
RiskGamma.....	407
RiskGammaAlt	407
RiskGeneral.....	408
RiskGeomet.....	409
RiskHistogrm	410
RiskHypergeo	411
RiskIntUniform	411
RiskInvgauss.....	412
RiskInvgaussAlt	412
RiskLogistic.....	412
RiskLogisticAlt	413

RiskLogLogistic.....	413
RiskLogLogisticAlt	413
RiskLognorm	414
RiskLognormAlt.....	414
RiskLognorm2	415
RiskNegbin	415
RiskNormal	416
RiskNormalAlt	416
RiskPareto.....	416
RiskParetoAlt.....	417
RiskPareto2.....	417
RiskPareto2Alt.....	417
RiskPearson5.....	418
RiskPearson5Alt.....	418
RiskPearson6.....	418
RiskPert.....	419
RiskPertAlt	419
RiskPoisson.....	419
RiskRayleigh.....	420
RiskRayleighAlt.....	420
RiskSimtable.....	420
RiskStudent.....	421
RiskTriang	421
RiskTriangAlt	421
RiskTrigen	422
RiskUniform	422
RiskUniformAlt.....	423
RiskWeibull	423
RiskWeibullAlt.....	423
Reference: Distribution Property Functions	425
RiskCollect	425
RiskCorrmat	426
RiskDepC	428
RiskFit	430
RiskIndepC	431
RiskLock	432
RiskName	432
RiskShift.....	432
RiskTruncate.....	433
Reference: Output Functions	435
RiskOutput.....	436
Reference: Statistics Functions	437
RiskData	437

RiskKurtosis	438
RiskMax	438
RiskMean	438
RiskMin	439
RiskMode	439
RiskPercentile	439
RiskRange	440
RiskSkewness	440
RiskStdDev	440
RiskStdDev	440
RiskTarget	441
RiskVariance	441
Reference: Supplemental Functions	443
RiskCurrentIter	443
RiskCurrentSim	443
Reference: Graphing Function	445
RiskResultsGraph	445
 Graphing Function	 445
 Reference: @RISK Macros	 447
Overview	447
Organization	447
Using the VBA Functions	447
Macro Example Files	448
Macros from Earlier Versions of @RISK	448
Using VBA to Modify @RISK Settings and Enter Outputs	449
Public Variable Type Used for @RISK Settings	449
Defining @RISK Settings Using Code	449
Adding Outputs and Distributions from VBA	450
Fitting Distributions to Data from VBA	450
Using VBA to Run Simulations, Get Results and Generate Reports	451
 Using VBA to Run Advanced Analyses	 453
Using the VBA Functions for Advanced Analyses	453

Introduction

This chapter describes the icons, commands, probability distribution functions and macros used to set up and execute a risk analysis using @RISK. The @RISK Reference Guide chapter is divided into six sections:

- 1) *Reference: @RISK Icons*
- 2) *Reference: @RISK Add-in Menu Commands*
- 3) *Reference: @RISK Model Window Commands*
- 4) *Reference: @RISK Results Window Commands*
- 5) *Reference: @RISK Functions*
- 6) *Reference: @RISK Macros*

Reference: @RISK Icons

@RISK icons are used to quickly and easily perform tasks necessary to set up and run risk analyses. @RISK icons appear in three places — on the spreadsheet "toolbar" (i.e., as a custom toolbar in Excel), in the @RISK Model window and in the @RISK Results window. Some of the same icons are available in each location. This section briefly describes each icon, outlining the functions they perform and the menu command equivalents associated with them.

A second toolbar titled *DecisionTools* is also available when @RISK for Excel is installed. This toolbar contains icons which can be used to run @RISK or any of the other programs in the DecisionTools suite (if these programs are installed on your system). For more information on the DecisionTools suite, see **Appendix B: Using @RISK With Other DecisionTools**.

@RISK Add-in Toolbar

The following icons are shown on the @RISK toolbar in Excel. **Note:** The @RISK add-in in Excel has two available toolbars – the **standard** toolbar and an **expanded** version that contains tools for the Advanced Analyses available in @RISK Professional and Industrial. Clicking the "expansion" icon at the end of the toolbar changes the toolbar from standard to expanded and back.

<i>Icon</i>	<i>Function Performed and Command Equivalent</i>
-------------	--



Open a saved @RISK simulation

Command equivalent: File menu Open command



Save the current @RISK simulation, including results and graphs

Command equivalent: File menu Save command



Add or edit probability distributions in the formula in the current cell

Command equivalent: Model menu Define Distributions command



Fits a distribution to the data in an Excel range (expanded toolbar only)

Command equivalent: Model menu Fit Distributions to Data command

Icon Function Performed and Command Equivalent



Add the current selected spreadsheet cell (or range of cells) as a simulation output

Command equivalent: Model menu Add Output command



Display current output cell(s) along with all distribution functions entered in the worksheet in the Outputs and Inputs list

Command equivalent: Model menu List Outputs and Inputs command



Select cells in Excel containing @RISK distribution functions, output functions or statistics functions

Command equivalent: Model menu Select @RISK Functions command



View or change the simulation settings, including # of iterations, # of simulations, sampling type, standard recalc method, executed macros and other settings

Command equivalent: Simulation menu Settings command



Display reporting options

Command equivalent: Results menu Report Settings command



Simulate the current worksheet(s)

Command equivalent: Simulation menu Start command



Run a Goal Seek analysis (expanded toolbar only)

Command equivalent: Advanced Analyses menu Goal Seek command



Run a Stress analysis (expanded toolbar only)

Command equivalent: Advanced Analyses menu Stress command



Run an Advanced Sensitivity Analysis (expanded toolbar only)

Command equivalent: Advanced Analyses menu Advanced Sensitivity Analysis command

Icon Function Performed and Command Equivalent



Display the Model window with outputs, inputs and fitting data

Command equivalent: Model menu Show Model Window command



Display the results of the most recent @RISK simulation in the Results window

Command equivalent: Results menu Show Results Window icon

@RISK Model Window Toolbar

The following icons are shown on the @RISK toolbar in the @RISK Model Window.

Icon Function Performed and Command Equivalent



Open a saved @RISK simulation

Command equivalent: File menu Open command



Save the current @RISK simulation, including results and graphs

Command equivalent: File menu Save command



Add or edit probability distributions in the formula in the current cell

Command equivalent: Model menu Define Distributions command



Display current output cell(s) along with all distribution functions entered in the worksheet in the Outputs and Inputs list

Command equivalent: Model menu List Outputs and Inputs command



Correlate probability distributions in the formulas in the selected cells

Command equivalent: Model menu Correlate Distributions command



Display report settings options

Command equivalent: Results menu Report Settings command



View or change the simulation settings, including # of iterations, # of simulations, sampling type, standard recalc method, executed macros and other settings

Command equivalent: Simulation menu Settings command



Simulate the current worksheet(s)

Command equivalent: Simulation menu Start command



Display the results of the most recent @RISK simulation in the Results window

Command equivalent: Window menu Show Results Window command



Display Excel and the @RISK add-in program

Command equivalent: Window menu Show Excel command



Fit distributions to data

Command equivalent: Fitting menu Run Fit command



Specify distribution(s) to fit

Command equivalent: Fitting menu Distributions command



Define Chi-Sq test binning

Command equivalent: Fitting menu Define Chi-Sq Binning command



Display input data options

Command equivalent: Fitting menu Input Data Options command



Sort input data

Command equivalent: Fitting menu Sort command



Generate random data

Command equivalent: Fitting menu Generate command



Transform data

Command equivalent: Fitting menu Transform command



Insert Fit Tab

Command equivalent: Insert menu Fit Tab command



Insert Artist Window

Command equivalent: Insert menu Artist Window command



Insert Distribution Window

Command equivalent: Insert menu Distribution Window command

**Insert Fit Results Window**

Command equivalent: Insert menu Fit Results Window command

**Insert Fit Results Window**

Command equivalent: Insert menu Fit Summary Window command

**Display current graph as a density graph**

*Command equivalent: Graph menu Format Graph command
Graph Type - Density option*

**Display current graph as a cumulative ascending line graph**

*Command equivalent: Graph menu Format Graph command
Graph Type - Cumulative Ascending option*

**Display current graph as a cumulative ascending area graph**

*Command equivalent: Graph menu Format Graph command
Graph Type - Cumulative Ascending option*

**Display graph format options**

Command equivalent: Graph menu Format Graph command

**Generate current graph as an Excel format graph**

Command equivalent: Graph menu Graph in Excel command

@RISK Results Window Toolbar

The following icons are shown on the toolbar in the @RISK Results Window, or when you right-click on an input or output in the Explorer list in the Results Window.

<i>Icon</i>	<i>Function Performed and Command Equivalent</i>
-------------	--



Open a saved @RISK simulation

Command equivalent: File menu Open command



Save the current @RISK simulation, including results and graphs

Command equivalent: File menu Save command



Display report settings options

Command equivalent: Results menu Report Settings command



View or change the simulation settings, including # of iterations, # of simulations, sampling type, standard recalc method, executed macros and other settings

Command equivalent: Simulation menu Settings command



Simulate the current worksheet(s)

Command equivalent: Simulation menu Start command



Display Excel and the @RISK add-in program

Command equivalent: Window menu Show Excel command



Display the Model window with outputs, inputs and fitting data

Command equivalent: Window menu Show Model Window command



Graphs the output or input which is selected in the Explorer

Command equivalent: Insert menu Graph command



Display summary statistics window

Command equivalent: Insert menu Summary Statistics command



Display detailed statistics window

Command equivalent: Insert menu Detailed Statistics command

**Display data window***Command equivalent: Insert menu Data command***Display sensitivity analysis window***Command equivalent: Insert menu Sensitivity command***Display scenario analysis window***Command equivalent: Insert menu Scenarios command***Graph tornado(s) of sensitivity analysis results***Command equivalent: Insert menu Graph command – Tornado Graph***Graph summary of simulation results for output range(s)***Command equivalent: Insert menu Graph command – Summary Graph***Display current graph as a histogram***Command equivalent: Graph menu Graph Type command – Histogram – Bars option***Display current graph as an area graph***Command equivalent: Graph menu Graph Type command – Histogram – Area Graph option***Display current graph as a fitted curve***Command equivalent: Graph menu Graph Type command – Histogram – Fitted Curve option***Display current graph as a cumulative ascending line graph***Command equivalent: Graph menu Graph Type command – Ascending Cumulative – Line option***Display current graph as a cumulative descending line graph***Command equivalent: Graph menu Graph Type command – Descending Cumulative – Line option*



Display current graph as a cumulative descending area graph

Command equivalent: Graph menu Graph Type command – Descending Cumulative – Filled option



Display current graph as a cumulative ascending area graph

Command equivalent: Graph menu Graph Type command – Ascending Cumulative – Filled option



Display graph format options

Command equivalent: Graph menu Format Graph command



Generate current graph as an Excel format graph

Command equivalent: Graph menu Graph in Excel command










Generate a quick , single page report on simulation results in Excel

Command equivalent: Report menu Quick Report command

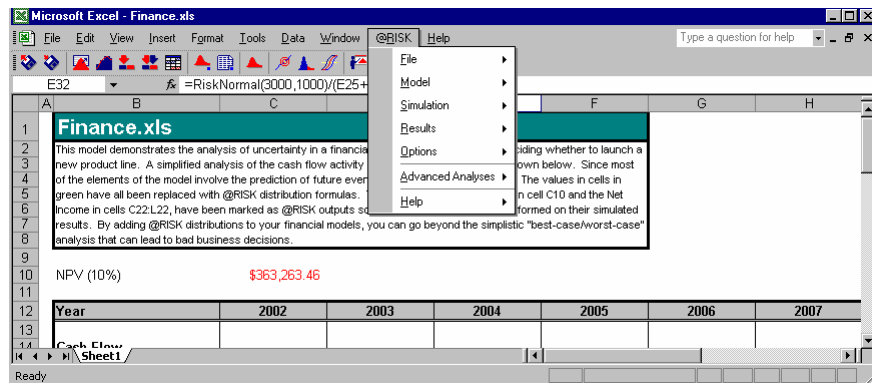
DecisionTools Toolbar

The following icons are shown on the DecisionTools Suite toolbar in Excel only.

<u>Icon</u>	<u>Functions Performed and Command Equivalent</u>
	Load the @RISK add-in. <i>Equivalent to the @RISK command on the Excel Tools menu.</i>
	Load the TopRank add-in. <i>Equivalent to the TopRank command on the Excel Tools menu.</i>
	Load the PrecisionTree add-in. <i>Equivalent to the PrecisionTree command on the Excel Tools menu.</i>
	Load the Evolver add-in. <i>Equivalent to the Evolver command on the Excel Tools menu.</i>
	Load the RISKOptimizer add-in. <i>Equivalent to the RISKOptimizer command on the Excel Tools menu.</i>
	Starts the BestFit program. <i>Starts the BestFit program for distribution fitting. @RISK Professional and Industrial users can access distribution fitting by selecting the Show Model Window command on the @RISK menu in Excel, followed by the @RISK Model window Insert menu Fit Tab command.</i>
	Display the Define Distribution pop-up window. <i>Equivalent to the Define Distribution command on the @RISK menu in Excel.</i>

Reference: @RISK Add-In Menu Commands

This section of the @RISK Reference Guide details the available @RISK commands as they appear on the @RISK add-in menu in Excel. Commands are discussed as they appear on the menu, starting with the File command and subsequently moving down the menu. @RISK icons can be used to perform many of the available commands. The **Reference: @RISK Icons** section of this chapter gives the command equivalents for each @RISK icon.



Several @RISK commands are also available in a pop-up floating menu that is displayed when the right mouse button is clicked on a cell in Excel.

File Menu

New Command

Clears all active @RISK simulation data and results

The New command clears all active @RISK simulation data from the Results and Model windows and resets @RISK settings to their default values.

Open Command

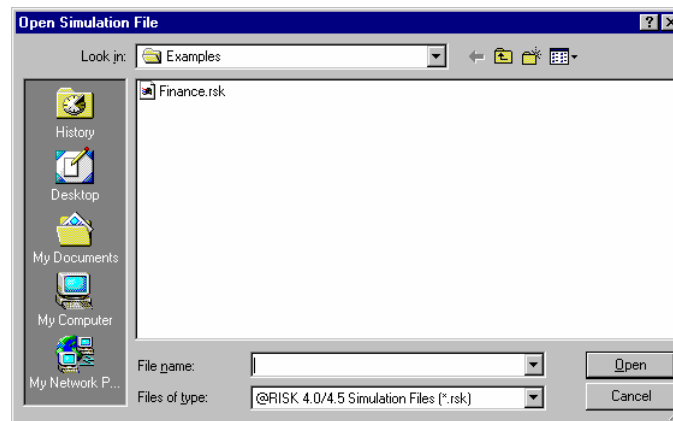
Opens a saved @RISK simulation

The File Open command opens a previously saved simulation data file (.RSK file or @RISK 3.5 .SIM file) including simulation settings, all input data and graphs (with supporting fitted datasets) and simulation results including any generated graphs.



Open Icon

Open Simulation File Dialog Box



When the File Open command is selected (or the Open icon is clicked), a standard Windows File Open dialog box is displayed. Using this dialog box, drives and directories can be changed and the desired @RISK .RSK file opened.

@RISK .SIM files must have been saved with @RISK Version 3.0 or higher.

@RISK will automatically load your simulation settings and specified outputs when you open a worksheet that was previously used with @RISK.

Save Command, Save As Command

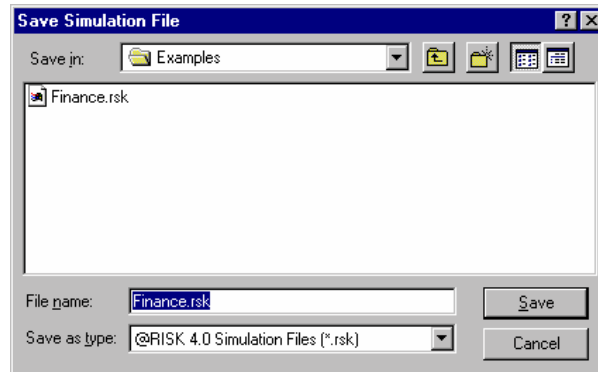
Saves the current @RISK simulation data or graph



Save Icon

The File menu Save and Save As commands save the current @RISK data in a .RSK file. The @RISK data saved includes the current input information in the Model window, any simulation results generated and any graphs created in the Results window. The File menu Save command automatically saves the .RSK file in the drive and directory where the worksheet being simulated was saved to.

**Save Simulation
File Dialog Box**



When the File menu Save As command is selected, a standard Windows File Save dialog box appears. Using this, a .RSK file may be saved to any desired drive or directory.

Saving your @RISK data does not save your worksheet with distribution functions. You need to save this separately using the Excel File Save commands.

Note if you rename a saved worksheet outside of Excel, any attached .RSK files will be unable to locate your workbook!

Exit Command

Unloads the @RISK add-in from Excel

The File menu Exit command unloads the @RISK add-in in Excel and shuts down the supporting @RISK-Model and @RISK-Results windows. If you shut down @RISK during an Excel session, you can restart it at a later time by clicking the @RISK icon on the DecisionTools toolbar.

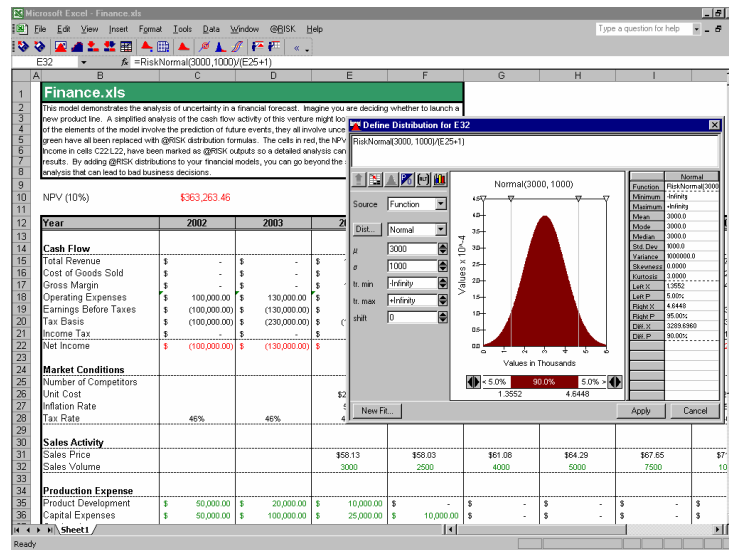
Model Menu

Define Distribution Command

Defines or edits probability distributions entered in the current cell formula

The Model menu Define Distribution command displays the Define Distribution pop-up window. Using this window, probability distributions can be assigned to values contained in the formula of the selected cell. This pop-up window also allows you to edit distributions already present in a cell's formula. All changes and edits made in the pop-up window are added directly to the cell's formula when the window is closed.

Define Distribution Window



By right-clicking on a cell in your spreadsheet and selecting the **@RISK Define Distribution** command (or by clicking the Define Distribution icon or selecting the @RISK menu Model Define Distributions command) you can display the Define Distribution pop-up window.

The @RISK Define Distribution window graphically displays probability distributions which can be substituted for values in the formula in the current cell. By changing the displayed distribution you can see how various distributions would describe the range of possible values for an uncertain input in your model. The displayed statistics further show how a distribution defines an uncertain input.

The graphical display of an uncertain input is useful in showing your definition of an uncertain input to others. It clearly displays the range of possible values for an input and the relative probability of any value in the range occurring. Working with distribution graphs you can easily incorporate other individual assessments of uncertainty into your risk analysis models.

Contents of the Define Distribution Window

The different elements of the Define Distribution window are as follows:

- **Cell Formula.** Displays the current cell formula including any @RISK distribution functions. *This formula may be edited here just as in Excel.*
- **Source.** Specifies the source of the distribution to be graphed, either **function**, **fit results** or **none**.
 - 1) **Function** specifies that distribution type and arguments are entered by the user directly in the window.
 - 2) **Fit Results** (Professional and Industrial Versions only) specifies that the distribution is from a fit result. For more on using fitting to select a distribution, see *Defining a Distribution By Fitting* later in this section.
 - 3) **None** removes any entered distribution. **None** typically is used to remove an overlay.

When source is set to **function**, the following items allow the entry of a distribution type and arguments:

- **Dist. and Arguments.** Selects a distribution type from all available distributions. Depending on the distribution type selected the displayed arguments will change. For distributions that take a set with a variable number of p or x,p values, a grid is displayed that allows entry of those values.
- **Tr. Min and Max.** Sets the minimum and maximum truncation limit for the entered distribution. When truncation values are entered, no values outside the truncation limits will be sampled.

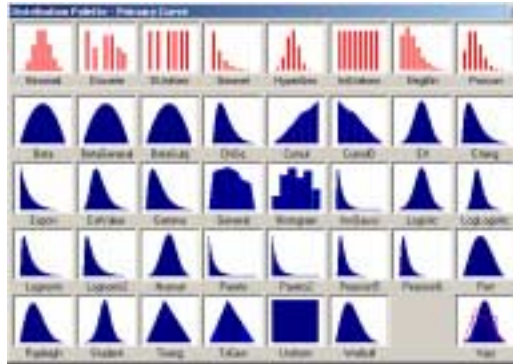
Delimiters and Statistics are used to display underlying statistics on displayed distribution graphs:

- **Delimiters** (marked with inverted triangles). Allows setting of target probabilities and x-axis scaling using the mouse. Cumulative probabilities can be set directly on a distribution graph using the displayed probability delimiters. Dragging probability delimiters changes **left** and **right x** and **p** values shown in the probability bar below the graph and in the statistics grid. Dragging the delimiters at either end of the x-axis rescales the x-axis.

- **Statistics.** Displays the statistics for the graphed distributions, including any overlays. In addition, x and p values set using the delimiters in the statistics grid to the right of the distribution graph are also shown.

Distribution Palette

- **Distribution Palette.** Clicking the **Dist...** button displays the Distribution Palette with graphical images of all available probability distribution types:



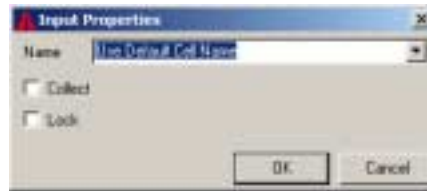
Clicking on the picture of a distribution selects it.

Icons in the Define Distribution Window



The following icons are available in the Define Distribution Window (as displayed left to right in the window):

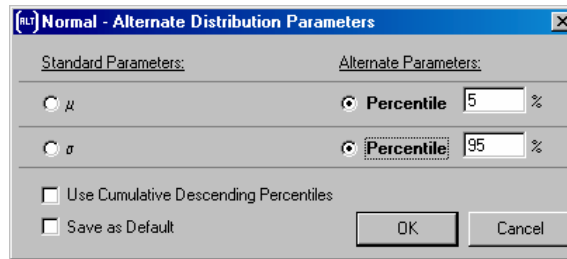
- **Insert Function.** Inserts the displayed distribution function into the cell formula, replacing the selected text in the formula.
- **Enter Reference.** Allows an Excel reference or formula to be entered for a distribution argument by pointing and clicking in Excel. Clicking this icon when the cursor is located in an argument entry text box displays a selector in Excel. This allows you to click on a cell or cell range that you wish to reference and use as an argument value.
- **Function Properties.** Displays the function properties for the selected distribution, including name, collect and lock status. The entry **Use Default Cell Name** indicates that @RISK will name your input using the labels for the cell where the distribution is located. **Collect** indicates that @RISK will collect the samples generated by the input during simulation (see the function **Collect** for more information on this). **Lock** indicates that @RISK will not sample the input during simulation (see the function **Lock** for more information on this).



- **Primary/Overlay Switch.** Switches the displayed graph and distribution information from the primary curve to the overlay curve. If no overlay is present on the graph, clicking the Primary/Overlay switch displays the **Distribution Palette** where a distribution type for the overlay can be selected.
- **Alternate Parameters.** Allows the selection of percentile parameters as arguments to the selected distribution.
- **Graph Formatting.** Displays the Graph Format dialog for changing type, scaling, style and titles for the displayed graph.

Alternate Parameters

Alternate Parameters allow you to specify values for specific percentile locations of an input distribution as opposed to the traditional arguments used by the distribution. The percentiles to be entered are specified in the Alternate Distribution Parameters dialog, displayed by clicking the ALT icon. Depending on the type of distribution being entered, the contents of the Alternate Distribution Parameters dialog will change.



Percentile parameters may be mixed with standard parameters by clicking the appropriate radio buttons. By selecting **Save as Default**, a set of percentile arguments may be set as the default for a given distribution type, so that every lognormal distribution, for example, will be entered in the Define Distribution window using a 10th and 90th percentile value.

Selecting **Use Cumulative Descending Percentiles** specifies that the percentiles used for alternate parameters will be in terms of cumulative descending probabilities. Percentiles entered in this case specify the probability of a value greater than the entered argument x-value.

Entering and Editing Distributions in the Define Distribution Window

To replace a value in the formula with a distribution function:

- 1) Select the value to be replaced by highlighting it in the Cell Formula.
- 2) Select and graph the desired distribution function.
- 3) Click the replace arrow below the Cell Formula box. The desired distribution (in the form of a probability distribution function) will replace the selected value in the formula.

To display the graph of a contained distribution function:

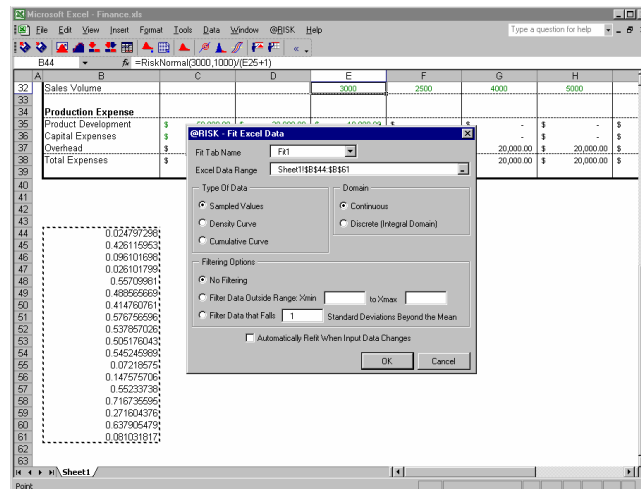
- 1) Right-click anywhere inside the distribution function entry. It will be displayed underlined and in red and the graph of the distribution will be displayed.
- 2) Any changes to the displayed distribution will be automatically made to the distribution selected in the cell formula.

Fitting from the Define Distribution Window (Professional and Industrial Versions)

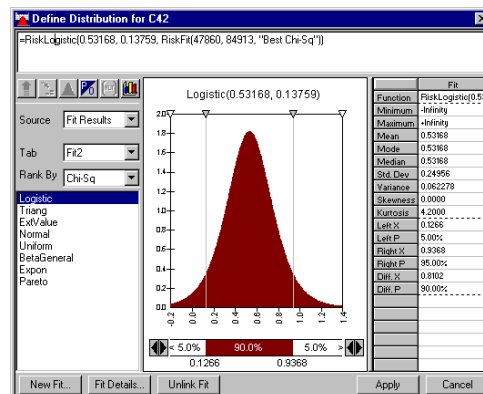
In some cases an input distribution is selected by fitting probability distributions to a set of data. You may have a set of sample data for an input and you wish to find the probability distribution that best describes that data. A fit tab in the @RISK Model Window has all the commands necessary for fitting distributions to data. This fitting can also be accessed directly from the Define Distribution window to allow you to quickly perform fits and then assign fit results to a model input.

To perform a new fit and assign a fit result to a model input:

- 1) Click the **New Fit** button in the Define Distribution window. A dialog is displayed that allows you to select a range of data in Excel to fit, along with the type and domain of data to be fitted.



- 2) After selecting your data and its type, click OK and probability distributions will be fit to the data. The Define Distribution dialog then shows a list of the fitted probability distributions, from best to worst. From this list you can select a distribution to use for the input.



Fit Excel Data Dialog

More information on the fit is available on the Fit Tab in the @RISK – Model window that is created when the fit was performed. Click **Fit Details** in the Define Distribution window to move to the tab for the current fit and change fitting options. For more information on @RISK – Model window fitting options, see the **Fitting Menu** commands in the Reference: @RISK – Model section of this manual.

The options available in the Fit Excel Data dialog include:

- **Fit Tab Name.** Specifies the name of the fit tab in the @RISK- Model window where the detailed information on the fit can be found.
- **Excel Data Range.** Identifies the location of the data in Excel to be fitted.

The additional options for input data in the Fit Excel Data dialog are the same as shown when the **Fitting Menu** Input Data Options command is selected. For more information on these options **Fitting Menu Input Data Options** command in the Reference: @RISK – Model section of this manual.

Linking with the RiskFit Function

Once you have selected a distribution from the list of fit results, the selected distribution function, including a **RiskFit** distribution property function, is shown in the top formula of the Define Distribution window. The RiskFit function maintains a link between the input distribution in your model and the fitted data and indicates what type of fit result, such as "*Best Chi-Sq*", you wish to use to select the distribution. If you update or change the data at a later time, the fit will automatically be recalculated and the new fitted distribution placed in your model. Distribution functions in Excel may be updated 1) immediately when a fit changes or 2) when the next simulation is run or the outputs and inputs list is generated. Use the @RISK Model window **Fitting menu Update @RISK Linked Functions** command to select when your distributions get updated. For more information on the RiskFit function, see the **Reference: @RISK Functions** section of this manual.

If no RiskFit function is used in the distribution function for a fit result, the distribution will be "unlinked" from the data which was fitted to select it. If the data is later changed the distribution will remain as is.

Add Output Command

Adds a cell or range of cells as a simulation output or output range



Add Output icon

Selecting the Model menu Add Output command (or clicking the Add Output icon) adds the currently selected range of worksheet cells as a simulation output. A distribution of possible outcomes is generated for every output cell selected. These probability distributions are created by collecting the values calculated for a cell each iteration of a simulation.

A Summary graph may be generated when a selected output range has more than one cell in it. For example, in one output range, you could select all the cells in a row in your worksheet. The output distributions from these cells would be summarized in a Summary graph. You could also see an individual probability distribution for any cell in the range.

Sensitivity and Scenario analysis results are also generated for each output cell. For more information on these analyses, see the descriptions of these analyses in Results Window section of this chapter.

RiskOutput Functions

When a cell is added as a simulation output a RiskOutput function is placed in the cell. These functions allow the easy copying, pasting and moving of output cells. RiskOutput functions may also be entered in formulas the same way you would type in any standard Excel function, bypassing the Add Output command. RiskOutput functions optionally allow you to name your simulation outputs and add individual output cells to output ranges. A typical RiskOutput function might be:

=RiskOutput("Profit")+NPV(.1,H1...H10)

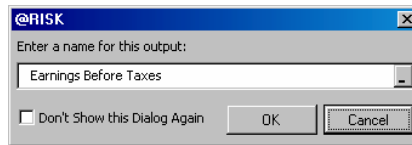
where the cell, prior to its selection as a simulation output, simply contained the formula

= NPV(.1,H1...H10)

The added RiskOutput function selects the cell as a simulation output and gives the output the name "Profit". For more information on RiskOutput functions, see the section: **Reference: @RISK Functions**.

Naming an Output

When an output is added, you are given the opportunity to name it or use the default name @RISK has identified. You can enter a reference to an Excel cell containing the name by simply clicking in the desired cell. The name (if not the @RISK default name) is added as an argument to the RiskOutput function used to identify the output cell.



At any time a name may be changed by editing the name argument to the RiskOutput function or by using the Model window Model menu **Function Properties** command. If you do not wish to individually name outputs and just use @RISK default names, select **Don't Show This Dialog Again**. If this is done, the Output Name dialog may be redisplayed by enabling the @RISK Add-in **Options menu Prompt For Output Names option**.

How To Add a Simulation Output

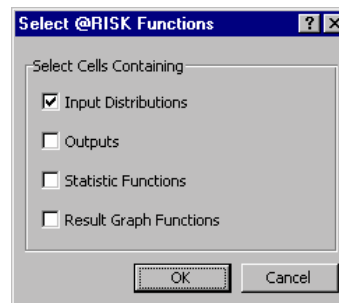
To add a new output range:

- 1) Highlight the range of cells in your spreadsheet that you wish to add as an output range. If multiple cells are included in the range, highlight all the cells by dragging the mouse.
- 2) Click the Add Output icon (the one with the single red arrow). The selected range of cells will be added as outputs and RiskOutput functions will be entered.
- 3) To view the outputs in the Outputs and Inputs list, click the List icon (the one with both a blue and red arrow) or select the @RISK Model menu List Outputs and Inputs command.

Select @RISK Functions Command

Selects cells in Excel containing @RISK functions

The Select @RISK Functions command selects cells in Excel containing @RISK distribution functions, output functions, statistics functions or graphing functions.



Using the Select @RISK Functions command you can quickly identify and format cells containing @RISK functions so they can easily be identified.

Fit Distributions to Data Command

Fits probability distributions to data in Excel and displays the results on a fit tab in the @RISK-Model window



***Fit Distributions
to Data icon***

The Model menu Fit Distributions to Data command (also invoked by clicking the **Fit Distributions to Data icon** on the expanded toolbar) fits probability distributions to the data in a selected Excel range. The Fit Excel Data dialog allows you to select the data in Excel you want to fit and its type. Once fitting is done, the selected data and the results of the fit are shown on a fit tab in the @RISK-Model window.

For more information on using the Fit Excel Data dialog, see **Fit Excel Data Dialog** under the Define Distributions command in this section. For more information on @RISK – Model window fitting options and results, see the **Fitting Menu** commands in the Reference: @RISK – Model section of this manual.

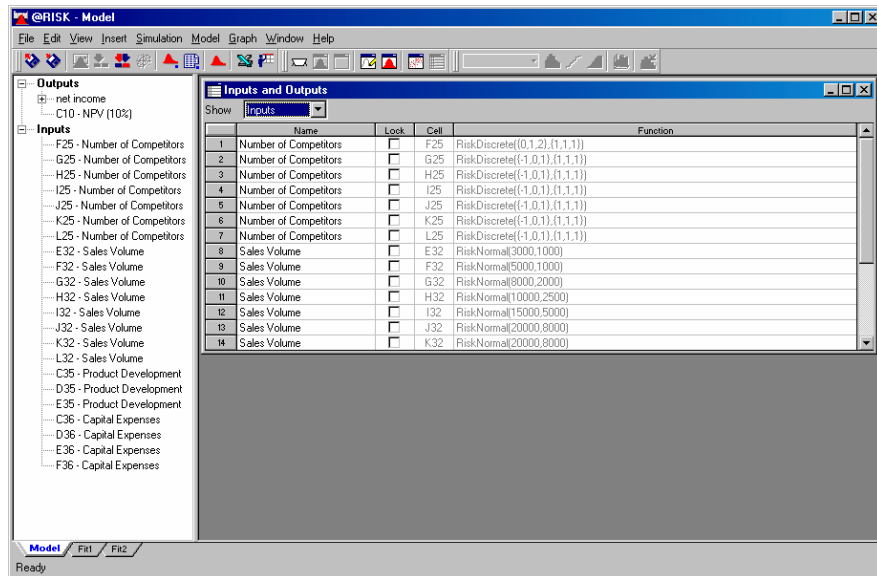
List Outputs and Inputs Command

Displays the Outputs and Inputs list in the Model window, listing output cells and distribution functions in your worksheet(s)



List Icon

The Model menu List Output and Inputs command (or clicking the List icon) shows all selected output cells and all identified input distribution functions in your worksheet(s) in an Explorer list in the @RISK Model program. The Inputs and Outputs table displays all distribution and output functions in the model.



For each Output variable, the list and table show:

- **Cell Reference**, or the reference of the selected output cell.
- **Name**, or the name of the cell as determined by @RISK or which you have previously entered.

For each input distribution function, the list and table show:

- **Cell Reference**, or the reference of the input cell where the distribution function is located.
- **Name**, or the name of the cell as determined by @RISK or entered by you.

The Inputs and Outputs table also displays the cell reference of all entered inputs and outputs and their current **Lock** and **Collect** settings. Name, Collect and Lock information may be edited in this table.

How is the Outputs and Inputs List Created?

The Outputs and Inputs list is set up automatically when you select to display the list. When the list is displayed, your worksheets are scanned or re-scanned for @RISK functions.

As new distribution functions are found, they are added to the Inputs list. This list summarizes all your distribution functions — their cell address and the "name" of the cell they are located in.

If a name is not entered in a RiskOutput function or in a distribution function, @RISK will automatically try to create a name. These names are created by scanning the spreadsheet around the cell where the input or output is located. To identify names, @RISK moves from the input or output cell across the row of the spreadsheet to the left and up the column towards the top. It moves across these ranges of the spreadsheet until it finds a label cell, or a cell without a formula in it. It then takes these row and column "headings" and combines them to create a possible name for the input or output. Many times, in standard spreadsheets with row labels down the left and column labels across the top, this process results in accurate names. However, in some spreadsheets, automatic naming will pick up non-sensical labels. In these cases you will need to edit the names displayed in the Outputs and Inputs list in order to enter more meaningful names for your variables.

How Are Variable Names Generated?

Tip: If there is a significant delay as @RISK rescans your worksheet each time the Outputs and Inputs list is displayed, click the Show Model Window icon instead. If this is done, @RISK simply redisplayes your old Outputs and Inputs list and doesn't rescan the worksheet. To rescan, use the Model menu List Outputs and Inputs command or select the List icon.

Show Model Window Command

Shows the @RISK Model window

The Model menu Show Model Window command shows the @RISK Model window. This command redisplayes your old Outputs and Inputs list and doesn't rescan the worksheet. To rescan, use the Model menu List Outputs and Inputs command or select the List icon.



**Show Model
Window icon**

Simulate Menu

Simulation Settings Command

Changes the settings which control the simulations performed by @RISK



**Simulation
Settings Icon**

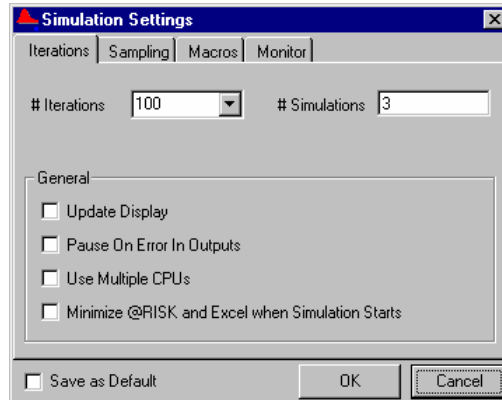
The Simulation Settings command affects the tasks performed during a simulation. All settings come with default values which you may change if you wish. The simulation settings affect the type of sampling @RISK performs, the updating of the worksheet display during simulation, the values returned by Excel in a standard recalculation, seeding of the random number generator used for sampling, the status of convergence monitoring and macro execution during simulation. All simulation settings are saved when you save a simulation using the @RISK File menu Save command.

Note: To save simulation settings so they will be used as the default settings each time you start @RISK, use the Save as Default button in the Settings dialog box.

Year	2002	2003	2004	2005	2006	2007
Cash Flow						
Total Revenue	\$ -	\$ -	\$ 174,375.00	\$ 145,078.13	\$ 244,331.25	\$ 321,434.77
Cost of Goods Sold	\$ -	\$ -	\$ 69,750.00	\$ 61,031.25	\$ 102,532.50	\$ 134,573.91
Gross Margin	\$ -	\$ -	\$ 104,625.00	\$ 84,046.88	\$ 141,798.75	\$ 186,860.86
Operating Expenses	\$ 100,000.00	\$ 130,000.00	\$ 55,000.00	\$ 30,000.00	\$ 20,000.00	\$ 20,000.00
Earnings Before Taxes	\$ (100,000.00)	\$ (130,000.00)	\$ 49,625.00	\$ 54,046.88	\$ 121,798.75	\$ 166,860.86
Tax Basis	\$ (100,000.00)	\$ (230,000.00)	\$ (180,375.00)	\$ (126,328.13)	\$ (4,529.38)	\$ 162,331.48
Income Tax	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 74,672.48
Net Income	\$ (100,000.00)	\$ (130,000.00)	\$ 49,625.00	\$ 54,046.88	\$ 121,798.75	\$ 92,188.38
Market Conditions						
Number of Competitors			0	1	1	1
Unit Cost			\$23.25	\$24.41	\$25.63	\$26.91
Inflation Rate			5%	5%	5%	5%
Tax Rate	46%	46%	46%	46%	46%	46%
Sales Activity						
Sales Price			\$58.13	\$58.03	\$61.08	\$64.29
Sales Volume			3000	2500	4000	5000

Iterations Tab – Simulation Settings Command

Allows entry or modification of the number of iterations and simulations which will be executed, as well as actions to perform each iteration



- **# Iterations.** Allows entry or modification of the number of iterations which will be executed during a simulation. Any positive integer value can be entered for # Iterations. The default value is 100. In each iteration:
 - 1) All distribution functions are sampled.
 - 2) Sampled values are returned to the cells and formulas of the worksheet.
 - 3) The worksheet is recalculated.
 - 4) New calculated values in the cells of the selected output ranges are saved for use in creating output distributions.

The number of iterations performed will affect both your simulation execution time and the quality and accuracy of your results. To get a quick look at results, run 100 iterations or less. For the most accurate results you will probably need to run 300 or 500 (or more) iterations. Use the Convergence Monitoring options (described in this section) to run the amount of iterations required for accurate and stable results.

The Excel Tools menu Options Calculation command Iterations option is used for solving worksheets which contain circular references. You may simulate worksheets which use this option as @RISK will not interfere with the solution of circular references. @RISK allows Excel to "iterate" to solve circular references each iteration of a simulation.

Important! A single recalc with sampling, done with the Standard Recalc Monte Carlo option on, possibly will not resolve circular references. If an @RISK distribution function is located in a cell which is recalculated during an Excel iteration, it will be resampled each iteration of the single recalc. Because of this, the Standard Recalc Monte Carlo option should not be used for worksheets which use Excel Iterations capabilities to solve circular references.

- **# Simulations.** Allows entry or modification of the number of simulations which will be executed in an @RISK simulation. You can enter any positive integer value. The default value is 1. In each iteration of each simulation:
 - 1) All distribution functions are sampled.
 - 2) SIMTABLE functions return the argument corresponding to the number of the simulation being executed.
 - 3) The worksheet is recalculated.
 - 4) New calculated values in the cells of the selected output ranges are saved for use in creating output distributions.

The number of simulations requested should be less than or equal to the number of arguments entered into the SIMTABLE functions. If the number of simulations is greater than the number of arguments entered into a SIMTABLE function, the SIMTABLE function will return an error value during a simulation whose number is greater than the number of arguments.

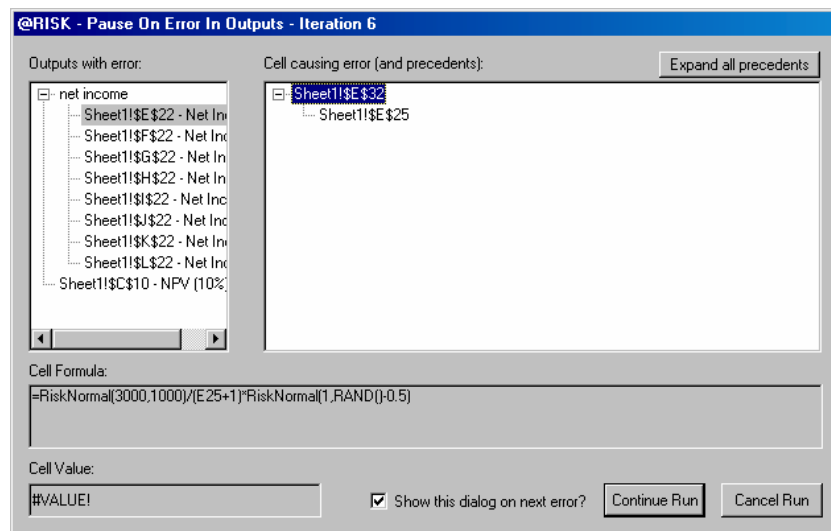
For more information on Sensitivity Simulation and using the SIMTABLE function, see **Chapter 5: @RISK Modeling Techniques**.

Important! Each simulation executed when the # Simulations is greater than one uses the same random number generator seed value. This isolates the differences between simulations to only the changes in the values returned by SIMTABLE functions. If you wish to override this setting, select Multiple Simulations Use Different Seed Values in the Random Number Generator section of the Sampling tab prior to running multiple simulations.

- **Update Display.** Toggles on and off the updating of the worksheet display during a simulation. For each iteration of a simulation, all distribution functions are sampled and the spreadsheet is recalculated. Update Display allows you to either display the results of each recalculation on the screen (box checked) or suppress the display (no check). The default is off, as updating the display for new values every iteration slows down the simulation.

Note: The Update Display setting may also be changed while a simulation is running by pressing the <Num Lock> key.

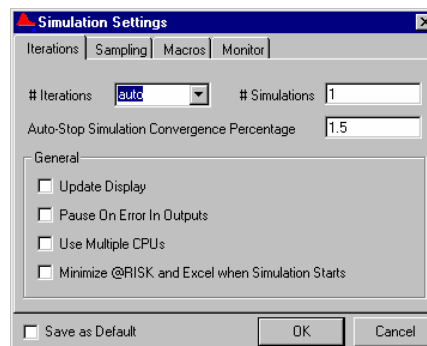
- **Pause on Error in Outputs.** Toggles the Pause on Error capability on and off. Pause on Error causes a simulation to pause if an Error value is generated in any output. When an error is generated, the Pause on Error in Outputs dialog provides a detailed listing of the outputs for which errors were generated during a simulation and the cells in your spreadsheet that caused the error.



The Pause on Error in Outputs dialog shows, on the left, an explorer list containing each output for which an error was generated. As you select an output with an error in the explorer list, on the right the cell whose formula caused the output's error value is displayed. @RISK identifies this cell by searching through the list of precedent cells for the output with the error until values switch from error to a non-error value. The last precedent cell(s) returning error prior to precedent cells returning non-error values is identified as the "error causing" cell.

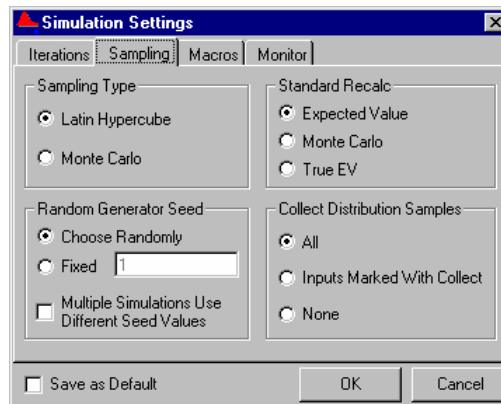
You can also review the formulas and values for cells which are precedents to the "error causing" cell by expanding the error-causing cell in the right-hand Explorer list. This allows you to examine values which feed into the problem formula. For example, a formula might return #VALUE because of a combination of values which are referenced by the formula. Looking at precedents to the error causing formula allows you to examine these referenced values

- **Use Multiple CPUs (@RISK Industrial only).** Instructs @RISK to use all CPUs present in your computer to speed simulations. **Note: this option is available only for users of @RISK Industrial running Windows NT 4.0 or higher.**
- **Minimize @RISK and Excel when Simulation Starts.** Minimizes the Excel window and all @RISK windows at the start of a simulation. Any window, however, can be viewed during the run by clicking it in the Task bar.
- **Auto-Stop Convergence Percentage.** When iterations are set to **Auto**, this setting controls whether @RISK should automatically halt the simulation when all output distribution statistics change less than the entered convergence threshold. This allows you to run a simulation without setting a number of iterations in advance. With Auto-Stop turned on, iterations will continue to be executed until convergence is achieved for all output distributions. The Auto-Stop feature can only be used for a single simulation (i.e. the "#Simulations" setting must equal 1).



Sampling Tab – Simulation Settings Command

Define sampling and recalculation settings for a simulation



Sampling Type

Sets the type of sampling used during an @RISK simulation. Sampling types vary in how they draw samples from across the range of a distribution. Latin Hypercube sampling will accurately recreate the probability distributions specified by distribution functions in fewer iterations when compared with Monte Carlo sampling.

We recommend using Latin Hypercube, the default sampling type setting, unless your modeling situation specifically calls for Monte Carlo sampling. The technical details on each sampling type are presented in the Technical Appendices.

- **Latin Hypercube.** Selects stratified sampling
- **Monte Carlo.** Selects standard Monte Carlo sampling

Standard Recalc

Specifies how distribution functions are evaluated during a regular Excel recalculation. When a recalc is executed (such as by selecting the Excel Options menu Calculate Now command or by pressing <F9>), distribution functions will return a value for use in worksheet recalculations. The type of value returned is set by the Standard Recalc options.

- **Expected Value.** Causes distribution functions (except discrete distributions) to return their expected or mean value during a regular Excel recalculation. For discrete distributions, the setting Expected Value returns the discrete value in the distribution closest to the true expected value. The Expected Value setting allows your worksheet values to appear just as they would without @RISK with a single expected value displayed in each cell. This is the default setting for Standard Recalc.

- **Monte Carlo.** Causes distribution functions to return a random Monte Carlo sample during a regular recalculation. This setting allows your worksheet values to appear as they would during execution of a simulation with new samples drawn for distribution functions each recalculation.
- **True EV.** Causes all distribution functions including discrete distributions to return their expected or mean value during a regular Excel recalc. This setting causes the same values to be returned as the option Standard Recalc Expected Value, except in the case of discrete distribution types such as DISCRETE, POISSON and similar distributions. For these distributions the true expected value will be returned in an Excel recalc even if the expected value could not occur for the entered distribution, i.e., it is not one of the discrete points in the distribution.

**Random
Number
Generator Seed**

Allows the entry of a seed value for the random number generator. The options for random number generator seed are:

- **Choose Randomly,** i.e., have @RISK randomly pick a new seed each simulation.
- **Fixed,** i.e., have @RISK use the same seed each simulation. When you enter a fixed non-zero seed value for the random number generator, the exact same sequence of random numbers will be repeated simulation to simulation. Random numbers are used in drawing samples from distribution functions. The same random number will always return the same sampled value from a given distribution function. The seed value must be an integer in the range 1 to 2147483647.

Setting a fixed seed value is useful when you wish to control the simulation sampling environment. For example, you may want to simulate the same model twice, only changing the argument values for one distribution function. By setting a fixed seed, the same values will be sampled each iteration from all distribution functions except the one you changed. Thus, the differences in the results between the two runs will be directly caused by changing the argument values of the single distribution function.

- **Multiple Simulations Use Different Seed Values,** i.e., have @RISK use a different seed each simulation in a multiple simulation run. If a **Fixed** seed is used and **Multiple Simulations Use Different Seed Values** is selected, each simulation will use a different seed but the same sequence of seed values will be used each time the run is re-executed. Thus, results will be reproducible run to run.

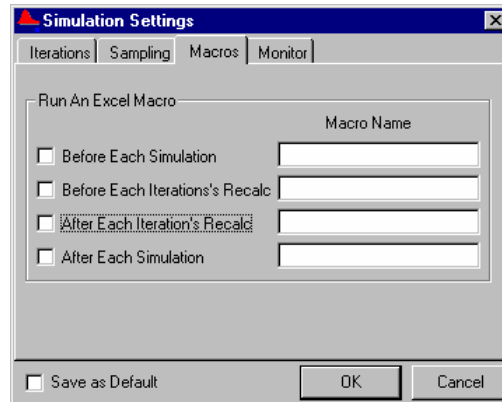
Collect Distribution Samples

The **Collect Distribution Samples** options specify how @RISK will collect random samples drawn from input distribution functions during a simulation.

- **All.** Specifies that samples will be collected for all input distribution functions.
- **Inputs Marked with Collect.** Specifies that samples will be collected for only those input distributions for which the Collect property is selected; i.e., a RiskCollect property function is entered inside the distribution. Sensitivity and Scenario analyses will only include those distributions marked with Collect.
- **None.** Specifies that no samples will be collected during a simulation. If no samples are collected, Sensitivity and Scenario analyses will not be available as simulation results. In addition, statistics will not be provided on samples drawn for input distribution functions. Deselecting sample collection, however, does allow simulations to run faster and will sometimes allow large simulations with many outputs to be run on memory constrained systems.

Macro Tab – Simulation Settings Command

Allows the specification of an Excel command macro to be executed before, during or after a simulation



The Run an Excel Macro option allows spreadsheet macros to be executed during an @RISK simulation.

When Does a Macro Execute?

- A macro can be run **Before Each Simulation**, **Before Each Iteration's Recalc** (i.e., before @RISK performs its sampling and worksheet recalc), **After Iteration's Recalc** (after @RISK performs its sampling and associated worksheet recalc) and **After Each Simulation**. Macros can be run at any or all of the possible times during a simulation. This feature allows calculations which only can be performed through the use of a macro to be made during a simulation. Examples of such macro-performed calculations are optimizations, iterative "looping" calculations and calculations which require new data from external sources. In addition, a macro may include @RISK distribution functions which are sampled during the execution of the macro.
- **Macro Name.** Defines the macro to be run. Should be "fully qualified" – should contain the full address (including filename) of the macro to be run.

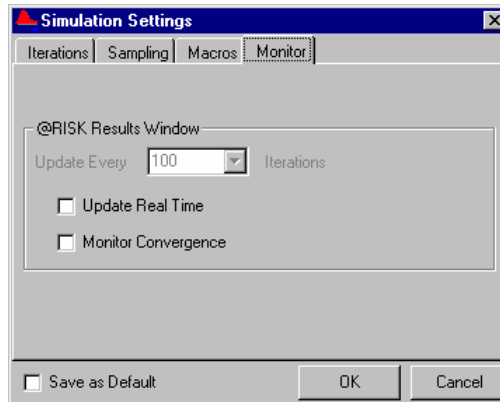
There are no restrictions on the operations performed by the macro each iteration. The user should, however, avoid macro commands which will do things such as close the worksheet being simulated, quit Excel or other similar functions.

***Running @RISK
from a Macro***

@RISK can be operated using custom VBA commands that have been added to Excel. This allows custom applications to be built using @RISK. These new commands are described in the **Reference: @RISK Macros** section of this chapter.

Monitor Tab – Simulation Settings Command

Define settings for updating Results windows and statistics functions during a simulation



The Monitor tab settings specify how graphs and reports in the @RISK – Results window, along with statistics functions in Excel, will be updated during a simulation. When updated, graphs, reports and statistics show current results based on the iterations run so far in the simulation. Convergence monitoring shows the amount statistics on output distributions are changing as additional iterations are run during the simulation.

@RISK Results Window

The @RISK Results Window options specify how @RISK – Results window graphs and reports and the Convergence Monitoring window update during a simulation.

- **Update Every XXXX Iterations.** Specifies the interval, in iterations, between updates of the selected windows and graphs.
- **Update Real-Time.** Selects the updating of Results window reports and graphs during a simulation. Graphs of simulation results and some report windows can be updated during simulation. With this option selected, the Results Window will automatically be displayed when a simulation starts and the updating of open windows will begin. A Real-Time Results toolbar is displayed in the Results window that allows you to control the updating of displayed reports and graphs.

- **Monitor Convergence.** Convergence monitoring can be performed during a simulation to track the stability of the output distributions being generated. As more and more iterations are executed during a simulation, the output distributions generated become more "stable". Distributions become stable because the statistics which describe them change less and less as additional iterations are performed. The number of iterations required to generate stable output distributions varies depending on the model being simulated and the distribution functions in the model.

By monitoring convergence you can ensure that you have run a sufficient, but not excessive, number of iterations. This is especially important with complex models that take a long time to recalculate.

Tip: Convergence monitoring does add to simulation runtime. If the fastest simulation is desired for a preset number of iterations, turn convergence monitoring off to maximize speed.

How Is Convergence Tested?

Convergence is monitored on three sets of statistics calculated for each output distribution. These statistics are:

- Percentiles (0% to 100% in 5% increments)
- Mean
- Standard Deviation

Monitoring convergence is done by calculating the above statistics on the data generated for each output cell at regular intervals throughout the simulation. The interval between updates is set by the **Update Every XXXX Iterations entry**. Each time new statistics are calculated the percentage change in statistics from the prior calculation is also determined. As this percentage change gets smaller, the impact on the statistics of running additional iterations decreases and the output distributions become more stable.

Convergence Monitoring Window

Cell	Name	% Chg in Prev	% Chg in Mean	% Chg in Std Dev	Minimum	Maximum	Mean	Std Dev
C22	Net Income	1.020%	-.897%	-2.19%	-196568.9	-13493.39	-1001.96	22440.87
D22	Net Income	144%	142%	-564%	-192617.7	-69716.14	-130815.6	20458.31
E22	Net Income	1.547%	1.248%	-.931%	-48615.78	148496.4	50210.04	33328.75
F22	Net Income	2.087%	1.377%	.894%	-6219.541	242468.7	76046.13	59124.04
G22	Net Income	2.114%	1.214%	-1.521%	3578.361	301530.8	115633.4	67742.6
H22	Net Income	1.045%	1.053%	1.415%	1884.317	361630.8	12955	75539.38
I22	Net Income	-4.123%	-.378%	-1.307%	-1564.916	6397.38.4	191055	139473.2
J22	Net Income	2.145%	2.083%	.882%	197036.2	959725.6	254953	206197.4
K22	Net Income	-.006722%	.622%	.254%	-36943.65	1225617	265922	228083.6
L22	Net Income	-3.411%	-1.944%	-.95%	-26410.42	1135359	265097.2	223338
C10	NPV (10%)	1.003%	.894%	1.73%	171541.49	1351456	467780.6	317305.6

The convergence monitoring window is displayed in the @RISK - Results window while a simulation is running. As each monitored statistic converges (i.e., it is changing less than the entered convergence threshold) it is highlighted. An output distribution with all three statistics converged is marked with a smile.

The **Convergence When Statistics Change <** entry at the top of the Convergence Monitoring window controls the maximum amount of change allowed for a converged distribution. When the statistics calculated change less than this entry for two consecutive calculations, the statistic is marked as converged (highlighted) in the monitoring screen. They may change back to "unconverged" or unhighlighted if subsequent monitoring shows a change in the statistic greater than the convergence threshold. It is important to remember that simulation, by nature, is a random process and there will always be some change in statistics with additional iterations. Realistically, a 0% change in statistics is unachievable no matter how many iterations you run.

The **Auto-Stop Simulation on Convergence** entry specifies whether a simulation will automatically stop when all output distributions converge. This setting is selected if the **# of Iterations** entry in the Simulation Settings dialog is set to **Auto**.

Start Simulation Command

Starts a simulation



Simulate Icon

The Simulation menu Start command (or clicking the Simulate icon) starts a simulation using the current settings. An executing simulation may be halted by clicking the Cancel button or pressing the <Esc> key. The Update Display option may be toggled on and off by pressing <Num Lock> during the simulation.

Results Menu

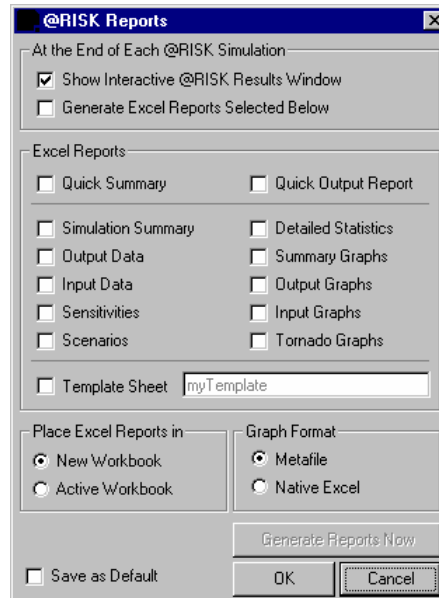
Report Settings Command

Specifies the location (Results window and/or Excel) that simulation results will be displayed and the type of reports that will be generated in Excel

The Results Report Settings command allows you to specify the location and type of simulation reports that will be generated. In addition, you can use this command to immediately generate reports in Excel on the most recently run simulation.



**Reports
Settings Icon**



The **At the End of Each @RISK Simulation** options specify where simulation results will be displayed at the end of a simulation. Available options include:

- **Show Interactive Results Window.** Causes the @RISK Results window to pop forward at the end of a simulation.
- **Generate Excel Reports Selected Below.** Generates the selected reports or graphs directly in Excel.

Both options can be selected if each type of reporting is desired.

Types of Reports in Available in Excel

A variety of different pre-built simulation reports are available directly in Excel at the end of a simulation. The first two Quick format reports are reports on simulation results designed for printing. The **Quick Summary** report summarizes an entire simulation run. The **Quick Output** report contains a single page report for each output in a simulation. The second section of available reports starting with **Simulation Summary** contain the same information as the equivalent report in the Results window. For more information as to the content of these reports, see the section **Reference: @RISK Results Window Commands** in this chapter.

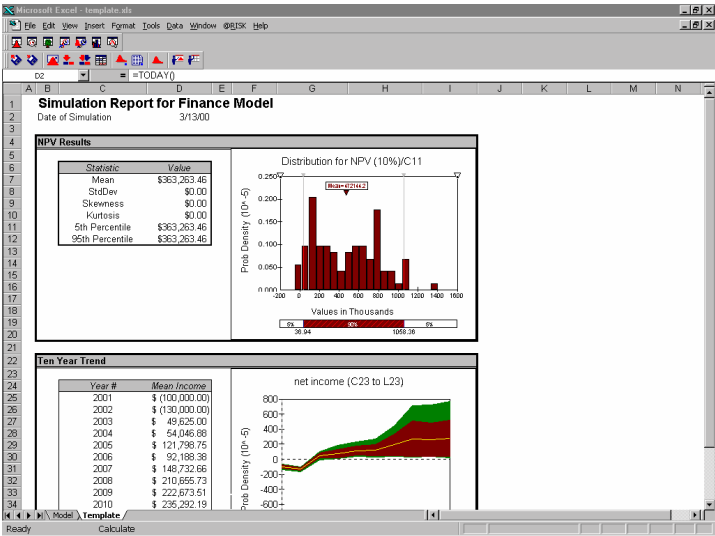
Two options are available for locating reports in Excel:

- **New Workbook.** Places simulation reports in a new workbook each time reports are generated.
- **Active Workbook.** Places simulation reports in new sheets in the active workbook each time reports are generated.

Template Sheets

You can use template sheets to create your own custom simulation report. Simulation statistics and graphs are placed in a template using @RISK statistics functions (such as **RiskMean**) or the graphing function **RiskResultsGraph**. When a statistics function or graphing function is located in a template sheet, the desired statistics and graphs are then generated at the end of a simulation in a copy of the template sheet to create your report. The original template sheet with the @RISK functions remains intact for use in generating reports from your next simulation.

Template sheets are standard Excel spreadsheets. They are identified to @RISK in the Reports Settings dialog box. These files can also contain any standard Excel formulas so custom calculations can be performed using simulation results.



The example file Template.XLS shown above contains a template sheet. You can review this sheet to see how to set up your own custom reports and template sheets.

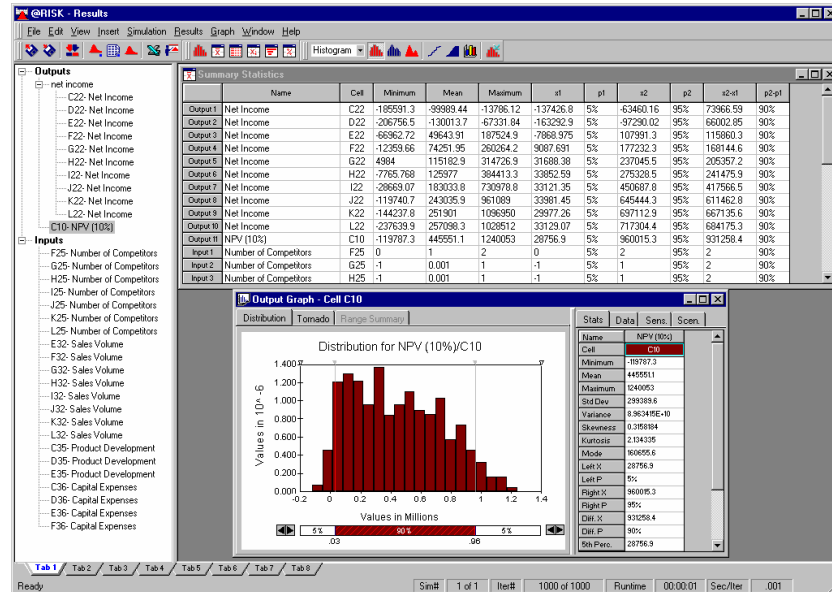
Show Results Window Command

Displays the @RISK Results window for viewing simulation results



Show Results Window Icon

The Results menu Show Results Window command shows the @RISK Results window. To redisplay Excel and the @RISK add-in program, select the @RISK Results Window menu Show Excel Window command or simply click on the Excel window.



Options Menu

Show Expanded Toolbar Command

Displays the expanded @RISK Professional and Industrial toolbar in Excel

The Options menu Show Expanded Toolbar command displays the expanded @RISK toolbar. This toolbar contains the icons for the advanced analyses available in @RISK Professional and Industrial. This toolbar may also be displayed by clicking the expansion icon at the end of the standard @RISK toolbar.

Prompt For Output Names Command

Turns the display of the @RISK output naming dialog on and off

The Options menu Prompt For Output Names command turns the automatic display of the output name dialog when outputs are added on or off. Turn this off to default to @RISK default names when outputs are added.

Display Cumulative Descending Percentiles Command

Displays cumulative descending percentiles in @RISK reports and sets them as the default for alternate parameter probability distributions

The Options menu Display Cumulative Descending Percentiles Command switches all @RISK statistics reports, targets and graph x and p values to display cumulative descending percentiles. By default, @RISK reports percentile values in terms of cumulative ascending percentiles, or the probability that a value is less than or equal to a given x value. Selecting this command causes @RISK to report cumulative descending percentiles, or the probability that a value is greater than a given x value.

Selecting Display Cumulative Descending Percentiles also causes @RISK to default to the entry of cumulative descending percentiles when alternate parameter distributions are entered in the Define Distribution window. In this case, the percentage chance of a value greater than the entered value is specified.

Advanced Analyses Menu

@RISK Professional and Industrial versions allow you to perform Advanced Analyses on your model. The Advanced Analyses include **Advanced Sensitivity Analysis**, **Stress Analysis**, and **Goal Seek**. These Advanced Analyses can be used to design your model, verify your model, or get many “What if?” kinds of results.

Each of the Advanced Analyses generates its own sets of reports in Excel to show the results of the analysis being run. However, each of the analyses uses standard @RISK multiple simulations to generate its results. Because of this the @RISK – Results window may also be used to review analysis results. This is useful when you wish to generate a graph of results that is not included in the Excel reports or when you wish to review analysis data in more detail.

Simulation Settings in Advanced Analyses

Simulation settings specified in the @RISK Simulation Settings dialog (except for **# of Simulations**) are those used in each of @RISK's Advanced Analyses. As many Advanced Analyses can involve large numbers of simulations, you should review your simulation settings to insure that analysis runtimes are minimized. For example, when testing the setup of an advanced analysis you should set the **# of Iterations** to a relatively low value until you have verified that your setup is correct. Then, set the **# of Iterations** back to the level necessary for stable simulation results and run the full Advanced Sensitivity Analysis, Stress Analysis, or Goal Seek.

Goal Seek

Goal Seek Command

Sets up and runs an @RISK Goal Seek

Goal Seek allows you to find a specific simulated statistic for a cell (for example, the mean or standard deviation) by adjusting the value of another cell. The setup of an @RISK Goal Seek is very similar to the standard Excel's Goal Seek. Unlike Excel's Goal Seek, however, @RISK's Goal Seek utilizes multiple simulations to find the adjustable cell value that achieves your results.

When you know the desired statistic value for an output but not the input value needed to obtain that value, you can use the Goal Seek feature. An input can be any cell in your Excel workbook. An output is any cell that is an @RISK simulation output (i.e., a cell containing a RiskOutput() function). The input should be a precedent of the output cell being targeted. When goal seeking, @RISK varies the value in the input cell and runs a full simulation. This process is repeated until the desired simulation statistic for the output equals the result you want.

Goal Seek is invoked by clicking the Goal Seek icon from the expanded @RISK toolbar, or via the @RISK Menu, Advanced Analyses Goal Seek command.

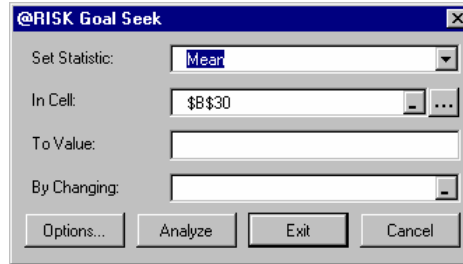


Goal Seek

Note: For a full tutorial on Goal Seek and the other @RISK 4.5 Advanced Analyses, run the on-line tutorial located in the DTOOLS\RISK45 directory.

@RISK Goal Seek Dialog

The options available in the @RISK Goal Seek dialog are as follows:

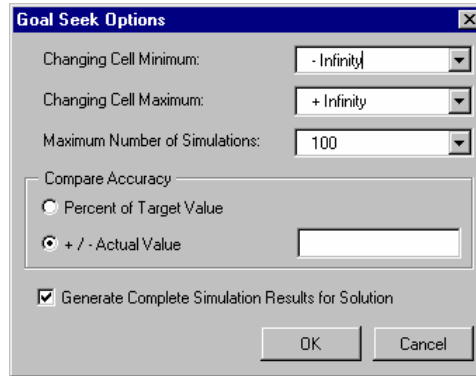


- **Set Statistic** - Allows you to choose which output statistic to monitor for convergence on the goal. The list includes: Minimum, Maximum, Kurtosis, Mean, Mode, Median, 5th Percentile, 95th Percentile, Skewness, Standard Deviation, and Variance.
- **In Cell** - Identifies the cell reference for the output whose simulation statistic you are trying to set to the entered value. This cell must be an @RISK output cell. If the cell does not contain a RiskOutput() function, you will be prompted to add a RiskOutput().
- **To Value** - Specifies the value you want the **Set Statistic** for **In Cell** to converge on. This value is called a goal.
- **By Changing** – Identifies the single cell that you want Goal Seek to change so that the **Set Statistic** for **In Cell** approximates the **To Value**. The **In Cell** must be dependent on the **By Changing** cell - if it is not, Goal Seek will not be able to find a solution.

Options Dialog – Goal Seek Command

Sets the analysis options for a Goal Seek

The Options dialog of Goal Seek allows you to set parameters that can affect the success and quality of the Goal Seek solution. The Options dialog is invoked by clicking the **Options** button in the Goal Seek dialog.



The entries in the Options dialog are as follows:

- **Changing Cell Minimum** - Allows you to set the minimum value to use for the **By Changing Cell**. Goal Seek attempts to bracket a solution by assuming that there is one between the Changing Cell Minimum and Changing Cell Maximum.
- **Changing Cell Maximum** - Allows you to set the maximum value to use for the **By Changing Cell**. Goal Seek attempts to bracket a solution by assuming that there is one between the Changing Cell Minimum and Changing Cell Maximum.
- **Maximum Number of Simulations** - Specifies how many simulations Goal Seek will attempt while trying to meet your goal. If a solution is found before all simulations are completed, simulation activity will halt and Goal Seek Status dialog will be displayed.

- **Compare Accuracy** - Determine how close the actual solution must be to the target. This entry can be viewed as a range around the desired target value that is acceptable for the simulation statistic. Any result within this range is defined as achieving the goal.
 - 1) **Percent of Target Value** - Specifies the accuracy as a percentage of the **To Value**.
 - 2) **+/- Actual Value** - Specifies the accuracy as the maximum difference between the goal and the value of the **In Cell** statistic found by Goal Seek.
- **Generate Complete Simulation Results for Solution** – If this is selected, after finding a solution Goal Seek performs an additional simulation that uses the found value for the **By Changing** cell. The statistics for that simulation are displayed in the @Risk – Results window. This option does not actually replace the original value of the **By Changing** cell with the found value in the spreadsheet. Instead, it enables you to see the effects such a replacement would have without performing it.

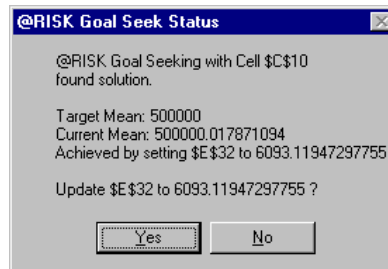
Analyze – Goal Seek Command

Runs a Goal Seek

Once Analyze is clicked, Goal Seek cycles through the following process until the goal statistic value is achieved or the maximum number of simulations are run:

- 1) A new value is placed in the changing input cell
- 2) A full simulation of all open workbooks is run using the current settings as specified in the @RISK Simulation Settings dialog box
- 3) @RISK records the simulation statistic selected in the **Set Statistic** entry for the output identified in the **In Cell** entry. This statistic value is compared to the **To Value** entry to see if the value achieves the goal (within the **Compare Accuracy** range entered)

If a solution is found within the requested accuracy, Goal Seek will display a Status dialog. This will allow you to replace the contents of the **Changing Cell** with the solution value. If you choose to do this, the entire cell contents will be replaced by the solution value, and any formula or values that were previously in that cell will be lost.



It is possible that Goal Seek will converge on a goal, but will not be able to converge within the requested accuracy. In this case Goal Seek will prompt you with its best solution.

How Are Input Values Selected in an @RISK Goal Seek?

An @RISK Goal Seek uses a two-tiered approach to converging on the target:

- 1) If no brackets are set using **Changing Cell Minimum and Maximum**, Goal Seek will attempt to bracket the target value using a geometric expansion around the original value.
- 2) Once a solution is bracketed, Goal Seek uses the **Ridders'** method of root finding. Using the Ridders' method, Goal Seek first simulates the model with the input value set to the midpoint of the bracketed range. It then factors out that unique Exponential function which turns the residual function into a straight line. This has some important benefits for the Goal Seek process. It insures that the tested input values never jump outside the brackets, and helps insure that Goal Seek moves toward a solution in as few cycles as possible (an important benefit when each "cycle" is a full simulation of your model!).

What if Goal Seek Cannot Find a Solution?

It is possible that Goal Seek may have problems converging on a solution. Some desired solutions may just be impossible to achieve, or the model may behave so unpredictably that the root finding algorithm cannot converge on a solution. You can help Goal Seek converge by:

- **Starting Goal Seek with a Different Value in the Changing Cell.** Because the iteration process begins with guesses around the original changing cell value, starting Goal Seek with a different value in the cell being changed may help.
- **Changing Your Brackets.** Setting the **Changing Cell Minimum** and **Changing Cell Maximum** in the Options dialog will help point Goal Seek toward a solution.

Note: Goal Seek is not designed to work with multiple simulation models. For RiskSimtable functions, the first value in the table will be used for all simulations.

Stress Analysis

Stress Analysis Command

Sets up and runs a Stress Analysis

Stress Analysis allows you to analyze the effects of stressing @RISK distributions. Stressing a distribution restricts samples drawn from the distribution to values between a specified pair of percentiles.

Alternatively, stressing can be done by specifying a new “stress” distribution that will be sampled instead of the original distribution in your model. With Stress Analysis you can select a number of @RISK distributions and run simulations while stressing those distributions jointly in one simulation or separately in multiple simulations. By stressing the selected distributions, you can analyze scenarios without changing your model.

After completing a simulation, Stress Analysis provides you with a collection of reports and graphs that you can use to analyze the effects of stressing certain distributions on a selected model output.

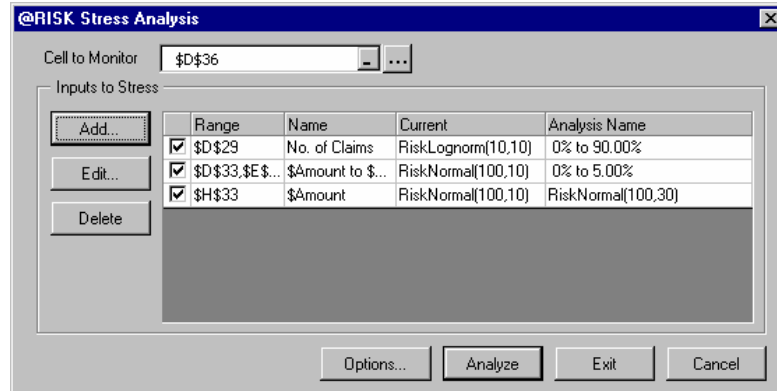
Stress Analysis is invoked by clicking the Stress Analysis icon from the expanded @RISK toolbar, or via the @RISK Menu, Advanced Analyses submenu.



Stress Analysis

Note: For a full tutorial on Stress Analysis and the other @RISK 4.5 Advanced Analyses, run the on-line tutorial located in the DTOOLS\RISK45 directory.

The options in the Stress Analysis dialog are as follows:



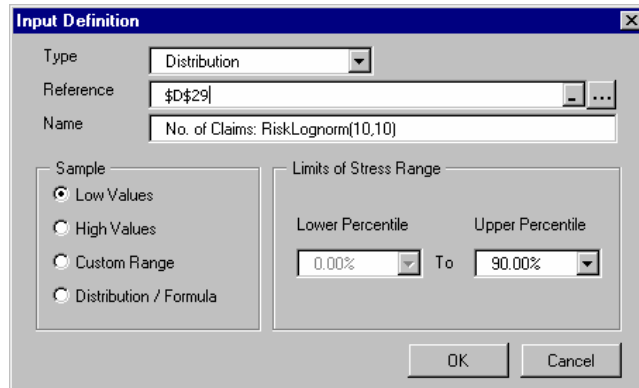
- **Cell To Monitor** - This is a single @RISK output that you want to monitor as the specified @RISK distributions are stressed. The Cell To Monitor can be specified by entering a cell reference, clicking the desired cell, or clicking the ... button. This button displays a dialog that contains a list of all @RISK outputs in currently open Excel workbooks.

The **Inputs to Stress** section allows you to **Add**, **Edit**, and **Delete** the @RISK Distributions that you wish to stress. The specified distributions are maintained in a list that contains the cell range, the @RISK Name, the Current distribution, and an Analysis Name that you can edit.

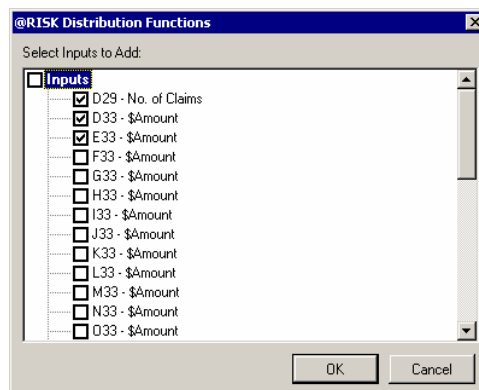
- **Add and Edit** - Display the **Input Definition** dialog. This allows you to specify an @RISK distribution or range of @RISK Distributions to be stressed. You can then select from **Low**, **High**, or **Custom** sampling ranges, or specify an alternate stress distribution or formula.
- **Delete** - Completely removes the @RISK distribution(s) that are highlighted on the list from the Stress Analysis. To temporarily exclude a distribution or a range of distributions from the analysis without deleting them, click the check box beside its list item to remove the checkmark.

Input Definition

The options in the Input Definition dialog are as follows:



- **Type** – For Stress Analysis, only @RISK distributions can be selected as inputs, so the only option for Type is **Distributions**.
- **Reference** – Selects the distributions to stress. Distributions can be specified by typing appropriate cell references, by selecting a range of cells in the worksheet, or by clicking the ... button, which will open the @RISK Distribution Functions dialog, listing all the distributions in the model.



The **Sample** options allow you to enter a range within the selected probability distribution(s) to sample from, or enter an alternate distribution or formula to substitute for the selected probability distribution(s) during the analysis.

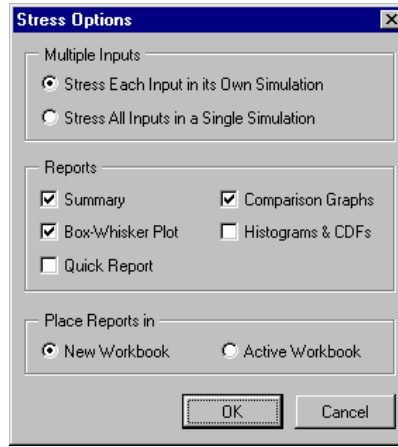
- **Low Values** – Enters a low range to sample from, bounded at the minimum by the distribution minimum. The Low Range default is 0% to 5%, sampling only values below the 5th percentile of the distribution. Any desired upper percentile can be entered instead of 5%.
- **High Values** – Enters a high range to sample from, bounded at the maximum by the distribution maximum. The High Range default is 95% to 100%, sampling only values above the 95th percentile. Any desired lower percentile can be entered instead of 95%.
- **From Custom Range** - Allows you to specify any percentile range within the distribution to sample from.
- **Distribution/Formula** - Allows you to enter an alternate @RISK distribution function (or any valid Excel formula) that will be substituted for the selected distribution during a Stress Analysis. You can use the **Excel Function Wizard** the help enter an alternate distribution by clicking the icon to the right of the Distribution/Formula box.

The screenshot shows the 'Input Definition' dialog box. It has a title bar with 'Input Definition' and a close button. Inside, there are three input fields: 'Type' with a dropdown menu showing 'Distribution', 'Reference' with the text '\$H\$33' and a selection icon, and 'Name' with the text '\$Amount: RiskNormal(100,10)'. Below these is a 'Sample' section with four radio buttons: 'Low Values', 'High Values', 'Custom Range', and 'Distribution / Formula' (which is selected). To the right of the 'Sample' section is a 'Distribution / Formula' section with a text box containing 'RiskNormal(100,30)' and an 'fx' icon. At the bottom right are 'OK' and 'Cancel' buttons.

Options – Stress Analysis Command

Sets the analysis options for a Stress Analysis

The Options dialog is used to determine how stressing will be performed and which reports or graphs to generate. The Options dialog is displayed when the Options button in the Stress Analysis dialog is clicked.



The **Multiple Inputs** section allows you to stress all of your specified @RISK distributions during one simulation, or to run a separate simulation for each @RISK distribution.

- **Stress Each Input in its Own Simulation** – Specifies that a full simulation will be run for each stress range entered. The only change made to the model during each simulation will be the stressing of a single input. The number of simulations run will equal the number of stress ranges entered.
- **Stress All Inputs in a Single Simulation** – Specifies that a single simulation will be run using all stress ranges entered. The simulation results will combine the effects of all stress ranges.

The **Reports** section allows you to choose which reports and graphs you want to be generated at the end of the stress simulations. The options include a **Summary** report, **Box-Whisker Plots**, **Comparison Graphs**, **Histograms**, **Cumulative Distribution Functions** and **Quick Reports**. For more information on the reports generated by a Stress Analysis, see **Reports** in this section.

The **Place Reports** section allows you to place your results in the active workbook, or a new workbook.

- **New Workbook** - All reports are placed in a new workbook
- **Active Workbook** – All reports are placed in the active workbook with your model

Analyze – Stress Analysis Command

Runs a Stress Analysis

Once you have selected the **Cell to Monitor**, and at least one @RISK distribution is specified to stress, you can click the **Analyze** button to run the analysis. The analysis runs one or more simulation(s) that restricts sampling of the selected @RISK distributions to the specified stress range(s) or substitutes in any alternate stress distributions or formulas you have entered. The results of the Stress Analysis simulations are organized in a summary sheet and several Stress Analysis graphs.

The results of the Stress Analysis are also available in the @RISK - Results window. This allows you to further analyze the results of stressing the @RISK inputs.

Reports

The Reports generated by a stress analysis include:

- **Summary report**
- **Box-Whisker Plots**
- **Comparison Graphs**
- **Histograms**
- **Cumulative Distribution Functions**
- **Quick Reports**

Summary Report

The **Summary** reports describes the stressed inputs, and the corresponding statistics of the monitored output: Mean, Minimum, Maximum, Mode, Standard Deviation, Variance, Kurtosis, Skewness, 5th Percentile and 95th Percentile.

Microsoft Excel - Book6

File Edit View Insert Format Tools Data Window @RISK Help

Type a question for help

K66

A B C D E F G H I J K L M N

1 @RISK Stress Analysis

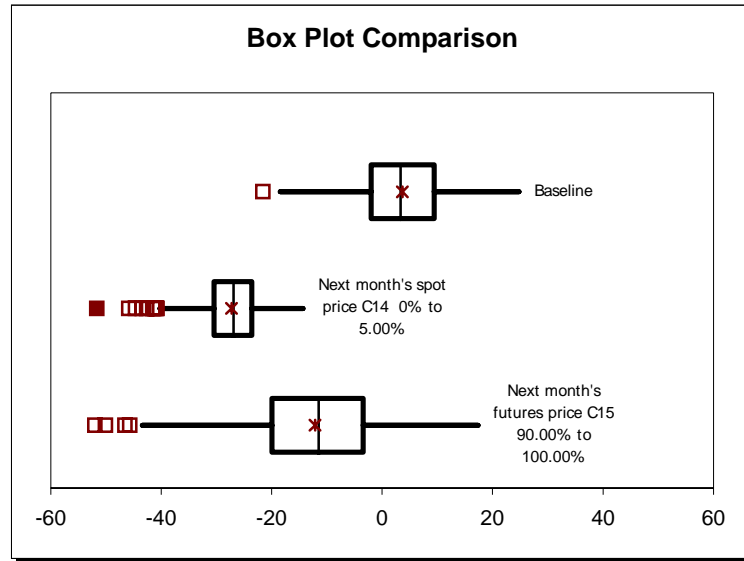
Input				Output: Total Payment Amount						
Name	Book	Cell	Stress Analysis	Mean	Min	Max	Mode	Median	StdDev	Var
(none)	(none)	(none)	baseline	907.1426563	0	3465.917725	587.5273031	611.2080688	783.4230865	613751.
No. of Claims	Claims.xls	\$D\$29	0% to 90.00%	698.0478377	0	1928.566772	591.4558105	586.0153198	470.1267057	221019.
\$Amount	Claims.xls	\$D\$33	0% to 5.00%	886.7051123	0	3438.40332	564.7921956	588.0933228	782.4473249	612223.
\$Amount	Claims.xls	\$E\$33	0% to 5.00%	888.0750937	0	3433.966064	277.6352437	593.2733765	781.9649642	611500.
\$Amount	Claims.xls	\$F\$33	0% to 5.00%	889.269165	0	3442.29126	375.4818014	591.225708	780.2200132	608745.
\$Amount	Claims.xls	\$G\$33	0% to 5.00%	891.1733215	0	3443.669678	554.3596191	590.0563965	776.7440628	606442.
\$Amount	Claims.xls	\$H\$33	RiskNormal(100,30)	910.6463025	0	3511.824951	398.2719625	628.0410767	786.0677041	616331.
\$Amount	Claims.xls	\$I\$33	0% to 5.00%	905.2104877	0	3426.508057	587.5273031	611.2080688	778.3674915	605855.
\$Amount	Claims.xls	\$J\$33	0% to 5.00%	905.473244	0	3438.67041	587.5273031	611.2080688	779.2519062	607233.
\$Amount	Claims.xls	\$K\$33	0% to 5.00%	905.233078	0	3447.825195	587.5273031	611.2080688	778.5945616	606209.
\$Amount	Claims.xls	\$AA\$33	0% to 5.00%	906.0328436	0	3450.524658	587.5273031	611.2080688	780.4205354	609056.
\$Amount	Claims.xls	\$AB\$33	0% to 5.00%	905.5814447	0	3440.496582	587.5273031	611.2080688	779.0036179	606846.
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\$Amount	Claims.xls	\$AD\$33	0% to 5.00%	906.1040765	0	3453.786621	587.5273031	611.2080688	780.2814114	608835.
\$Amount	Claims.xls	\$AE\$33	0% to 5.00%	906.5363026	0	3453.47998	587.5273031	611.2080688	781.5526769	610824.
\$Amount	Claims.xls	\$AF\$33	0% to 5.00%	906.3496405	0	3439.554932	587.5273031	611.2080688	780.9219908	609639.
\$Amount	Claims.xls	\$AG\$33	0% to 5.00%	906.2480511	0	3438.88916	587.5273031	611.2080688	780.628625	609378.
\$Amount	Claims.xls	\$AH\$33	0% to 5.00%	906.2759906	0	3438.145254	587.5273031	611.2080688	780.6880046	609470.
\$Amount	Claims.xls	\$AI\$33	0% to 5.00%	906.5424579	0	3434.914453	587.5273031	611.2080688	781.4805062	610711.
\$Amount	Claims.xls	\$AJ\$33	0% to 5.00%	906.5963177	0	3445.429199	587.5273031	611.2080688	781.6666371	611002.
\$Amount	Claims.xls	\$AK\$33	0% to 5.00%	906.6160541	0	3452.383057	587.5273031	611.2080688	781.7328654	611106.

Summary Summary Quick Report Comparison BoxPlot Histograms CDFs

Ready

Box-Whisker Plot

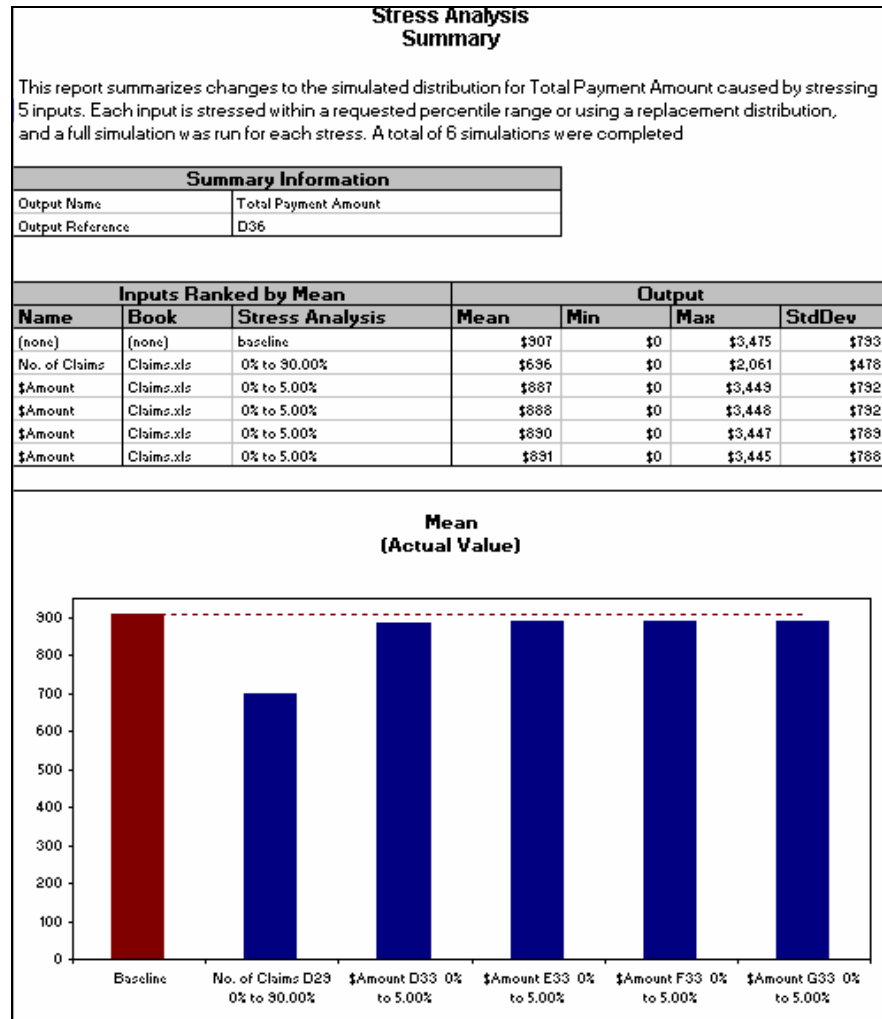
The **Box-Whisker Plot** gives an overall indication of the monitored output, describing the mean, median, and outlying percentiles.



The left and right of the box are indicators of the first and third quartiles. The vertical line inside the box represents the median, and the X indicates the location of the mean. The box width represents the interquartile range (IQR). The IQR is equal to the 75th percentile data point minus the 25th percentile data point. The horizontal lines extending from either side of the box indicate the first data point that is less than 1.5 times the IQR below the low edge of the box, and the last data point that is less than 1.5 times the IQR above the high edge of the box. Mild outliers, shown as hollow squares, are data points between 1.5 times IQR and 3.0 times IQR outside the box. Extreme outliers, shown as solid squares, are points beyond 3.0 times IQR outside the box.

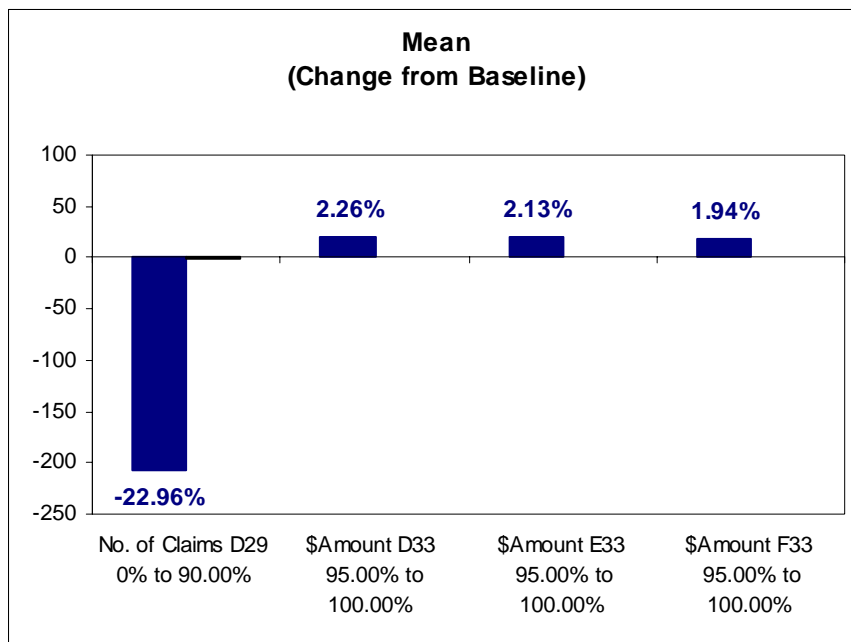
Quick Report

A Quick Report provides single page summary of the Stress Analysis as a whole. This reports is designed to fit on a single page.



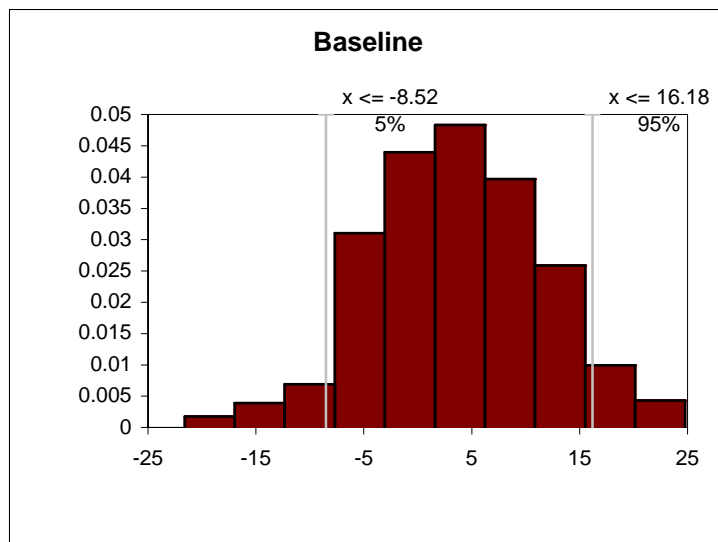
Comparison Graph

The four **Comparison Graphs** compare means, standard deviations, 5th percentiles, and 95th percentiles for each of the specified @RISK inputs (or their combination) and the Baseline simulation.



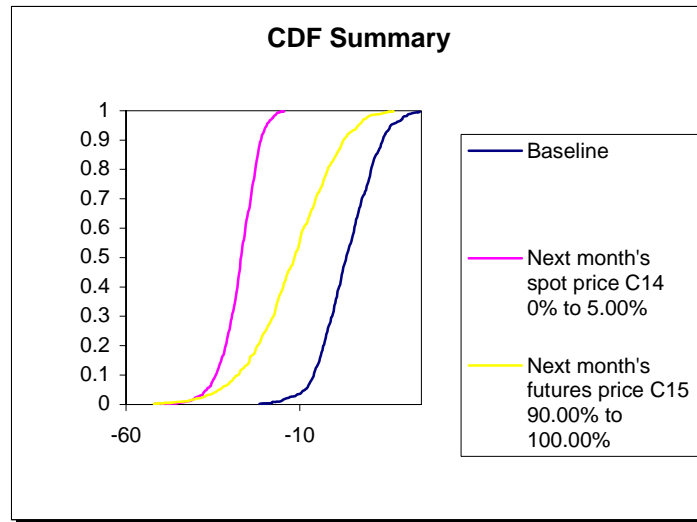
Histogram

The **Histograms** are standard @RISK histograms of the monitored output for each of the stressed inputs (or their combination) and the Baseline simulation.



Cumulative Summary

The **CDFs (Cumulative Distribution Functions)** are standard @RISK cumulative ascending density graphs. There is also a Summary CDF for all of the inputs.



Advanced Sensitivity Analysis

Advanced Sensitivity Analysis Command

Sets up and runs an Advanced Sensitivity Analysis

Advanced Sensitivity Analysis allows you to determine the effects of inputs on @RISK outputs. An input can be either an @RISK distribution or a cell in your Excel workbook. Advanced Sensitivity Analysis allows you to select a number of @RISK distributions or worksheet cells and run trial simulations while varying these inputs across a range. Advanced Sensitivity Analysis runs a full simulation at each of a set of possible values for an input, tracking the simulation results at each value. The results then show how simulation results changed as the input value was changed. As with the standard @RISK Sensitivity Analysis, the Advanced Sensitivity Analysis shows the sensitivity of an @RISK output to the specified input.

Advanced Sensitivity Analysis can be used to test the sensitivity of an @RISK output to the input distributions in a model. When testing an @RISK distribution, @RISK runs a set of simulations for the input. In each simulation, the input distribution is fixed at a different value across the min-max range of the distribution. Typically these "step" values are different percentile values for the input distribution.

Advanced Sensitivity Analysis is invoked by clicking the Advanced Sensitivity Analysis icon from the expanded @RISK toolbar, or via the @RISK Menu, Advanced Analyses submenu.

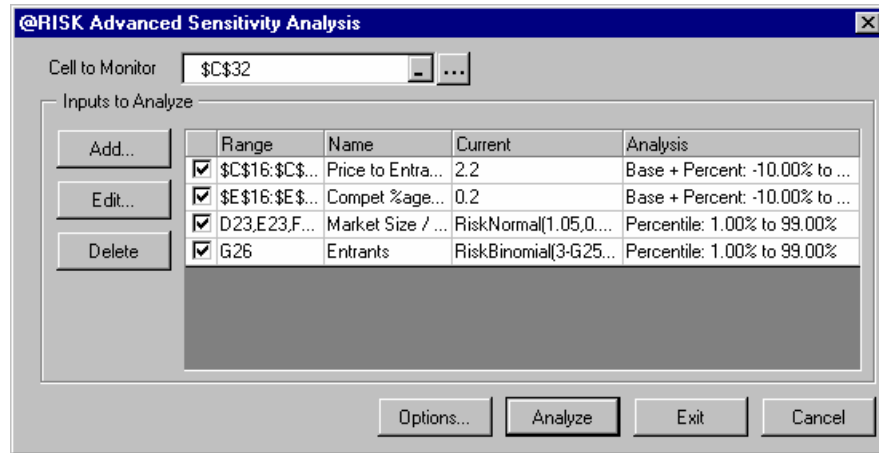


Advanced Sensitivity Analysis

Note: For a full tutorial on Advanced Sensitivity Analysis and the other @RISK 4.5 Advanced Analyses, run the on-line tutorial located in the DTOOLS\RISK45 directory.

Advanced Sensitivity Analysis Dialog

The options in the Advanced Sensitivity Analysis dialog are as follows:



- **Cell To Monitor** - This is a single @RISK output that you want to monitor as individual simulations are run while stepping across possible input values. The Cell To Monitor can be specified by entering a cell reference, clicking the desired cell, or clicking the ... button. This button displays a dialog that contains a list of all @RISK outputs in currently open Excel workbooks.

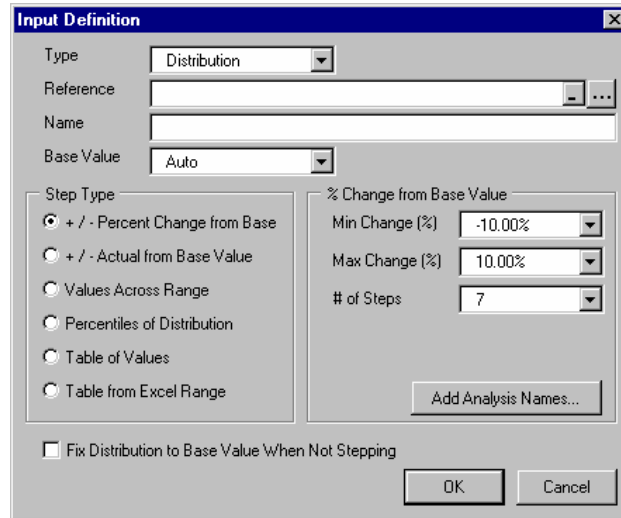
The **Inputs to Analyze** options allow you to **Add**, **Edit**, and **Delete** the worksheet cells and @RISK distributions that you wish to include in the analysis. The specified cells and distributions are maintained in a list that contains the cell range, the @RISK Name, the Current distribution, and an Analysis Name that you can edit.

- **Add and Edit** - Displays the **Input Definition** dialog. This allows you to specify either a single @RISK distribution or worksheet cell, or a range of @RISK distributions or worksheet cells to be analyzed.
- **Delete** - Completely removes inputs from the Advanced Sensitivity Analysis. To temporarily exclude an input or group of inputs from the analysis without deleting them, click the check box in the appropriate line in the list to remove the check mark from that input.

Input Definition - Advanced Sensitivity Analysis Command

Defines Inputs in an Advanced Sensitivity Analysis

The Input Definition dialog allows you to enter the **type** of an input, its **name**, a **base value** and data which describes **the possible values for the input** that you wish to test in the sensitivity analysis. A full simulation will be run at each value you enter for an input. The options in the Input Definition dialog are detailed in this section.

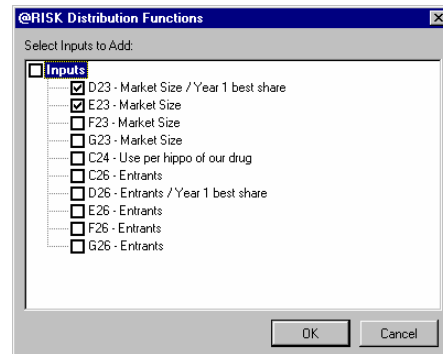


Type

Type specifies the type of input you are entering (either distribution or a worksheet cells). Inputs to an Advanced Sensitivity Analysis can be either **@RISK distributions** that have been entered into your worksheet formulas or worksheet **cells**.

Reference

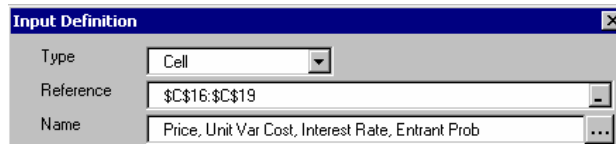
Reference specifies the worksheet location of your input(s). If you are selecting distribution input(s) you can click the ... button, which will open the @RISK Distributions Functions dialog, listing all the distributions in all open worksheets.



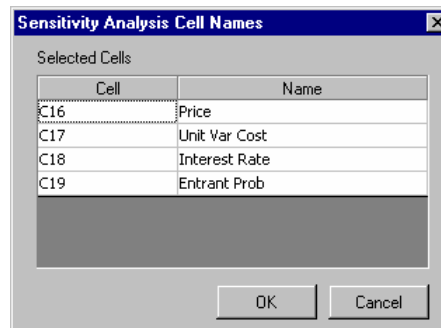
Name

Name names your input(s). If you are selecting distribution inputs the existing @RISK name for each input is shown. If you wish to use a different name for a distribution, simply change the @RISK name by adding a **RiskName** function to the distribution in Excel or by editing the name in the @RISK – Model window.

If you are selecting worksheet cells as inputs, the name of a single input can be typed directly in the Name entry. When you have selected a range of inputs, the Name entry shows the names of each cell, separated by commas.



Theses names can be edited by typing in the box (keeping the comma-separated format) or by clicking the ... button, which opens the **Sensitivity Analysis Cell Names** dialog.



Cell names are defined in the Input Definition dialog only for the purposes of Advanced Sensitivity Analysis. These names are used in @RISK Results window and in the reports generated by Advanced Sensitivity Analysis; however, these cell names do not become part of your Excel model.

Base Value

The **Base Value** is used to determine the sequence of values to step through for an input and as a reference point in the Percent Change report graph. The Base Value is especially important when you wish to apply a **Step Type** that is a change from base, such as +/- **Percent Change from Base**. By default, the Base Value is the value a distribution or cell evaluates to when Excel recalculates the worksheet, but you can change it to a different value. Note: If your distribution or cell evaluates to 0, and Base Value is set to **Auto**, you need to enter a non-zero base value if you use the +/- **Percent Change from Base** option.

Fix Distribution to Base Value When Not Stepping

If selected, **Fix Distribution to Base Value When Not Stepping** causes an input distribution to return its Base Value in the simulations when it is not the particular input being stepped across. This causes the distribution not to sample, essentially locking it to the entered **Base Value**. If Fix Distribution to Base Value When Not Stepping is not selected, the distribution will behave normally, that is, samples will be drawn from it in the simulations in which it is not being stepped across. **Note:** This option is not available when an input is a worksheet cell type.

Step Type - Advanced Sensitivity Analysis Command

Defines values to be used for inputs in an Advanced Sensitivity Analysis

The Step Type options describe the type of variation you will use to select the values that will be tested for your input(s). During an analysis, inputs are "stepped" across a range of possible values and a full simulation is run at each step value. The Step Type defines the nature of this range – either **+ / - Percent Change from Base**, **+ / - Actual from Base Value**, **Values Across Range**, **Percentiles of a Distribution**, **Table of Values**, or **Table from Excel Range**. These different step types provide a great deal of flexibility in describing the values to be tested for an input. Depending on the Step Type you select, the entry information for defining the actual range and step values (as shown on the right side of the Input Definition dialog) will change.

Each Step Type and its associated range and value entries is described here.

+ / - Percent Change from Base

With this Step Type, the first and the last value in the sequence to step through are obtained by incrementing or decrementing the input's **Base Value** by the percentage values specified in **Min Change (%)** and **Max Change (%)** entries. The intermediate values are at equal intervals, with the number of values to test is set by **# of Steps**.

The screenshot shows the 'Step Type' dialog box. On the left, under 'Step Type', the radio button for '+ / - Percent Change from Base' is selected. On the right, under '% Change from Base Value', the 'Min Change (%)' is set to -10.00%, 'Max Change (%)' is set to 10.00%, and '# of Steps' is set to 7. There is an 'Add Analysis Names...' button at the bottom right.

+ / - Actual from Base Value

With this Step Type, the first and the last value in the sequence to step through are obtained by adding to the Base Value the values specified in **Min Change** and **Max Change** entries. The intermediate values are at equal intervals, with the number of values to test is set by **# of Steps**.

The screenshot shows the 'Step Type' dialog box. On the left, under 'Step Type', the radio button for '+ / - Actual from Base Value' is selected. On the right, under 'Change from Base Value', the 'Min Change' is set to -5, 'Max Change' is set to 10, and '# of Steps' is set to 7. There is an 'Add Analysis Names...' button at the bottom right.

Values Across Range

With this Step Type, the sequence of values to step through starts at the **Minimum** and ends at the **Maximum**. The intermediate values are at equal intervals, with the number of values to test is set by **# of Steps**.

The screenshot shows the 'Input Definition' dialog box. On the left, under 'Step Type', the 'Values Across Range' option is selected. On the right, under 'Actual Min and Max Values', the 'Minimum' is 1.98, the 'Maximum' is 2.42, and the '# of Steps' is 7. An 'Add Analysis Names...' button is at the bottom right.

Percentiles of Distribution

This Step Type is only used when the selected input **Type** is **Distribution**. You specify steps as percentiles of the selected @RISK distribution, and you can define up to 20 steps. During the analysis, the input will be fixed at the percentile values as calculated from the entered input distribution.

The screenshot shows the 'Input Definition' dialog box. On the left, under 'Step Type', the 'Percentiles of Distribution' option is selected. On the right, under 'Percentile of Distribution', a list of percentiles is shown: 25.00%, 50.00%, 75.00%, 95.00%, and 99.00%. An 'Add Analysis Names...' button is at the bottom right.

Table of Values

With this Step Type, you enter the sequence of values to step through directly in a Table in the right portion of the Input Definition dialog. The Base Value is not used as the specific values you enter are the values tested.

The screenshot shows the 'Input Definition' dialog box. On the left, under 'Step Type', the 'Table of Values' option is selected. On the right, under 'Table', a list of values is shown: .1, .25, .4, .5, and .7. An 'Add Analysis Names...' button is at the bottom right.

Table from Excel Range

With this Step Type, the sequence of values to step through is found in the range of worksheet cells specified in **Excel Range** entry. This range can contain any number of values; however, it is important to remember that a full simulation will be run for each value in the referenced range.

Step Type

☐ + / - Percent Change from Base

☐ + / - Actual from Base Value

☐ Values Across Range

☐ Percentiles of Distribution

☐ Table of Values

☒ Table from Excel Range

Excel Range:

Add Analysis Names

By clicking the **Add Analysis Names** button, a descriptive name can be added to each input value that will be tested in an Advanced Sensitivity Analysis. This name will be used to identify the simulation run when an input is fixed at a particular value. These names will make your reports more readable and will help identify individual simulations when results are reviewed in the @RISK – Results window.

Sensitivity Analysis Names

G26

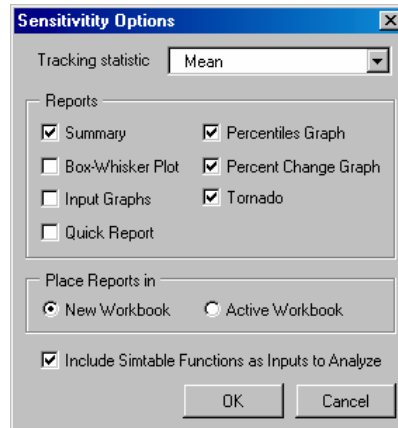
Value Used	Name
1.00%	Entrants: Lowest Value
5.00%	Perc: 5%
25.00%	Perc: 25%
50.00%	Perc: 50%
75.00%	Perc: 75%
95.00%	Perc: 95%
99.00%	Entrants: Highest Value

The **Sensitivity Analysis Names** dialog allows you to enter a name for the simulation to be run at each stepped input value. The default name @RISK has created is initially shown and you can change this as desired.

Options - Advanced Sensitivity Analysis Command

Defines analysis options for an Advanced Sensitivity Analysis

The Sensitivity Options dialog allows you to select the output statistic you wish to evaluate during the sensitivity analysis, identify the reports you want to generate and specify the behavior of @RISK Simtable functions in the analysis.



The Sensitivity Options dialog is invoked by clicking the **Options** button from the main Advanced Sensitivity Analysis dialog. The selections in this dialog include:

- **Tracking Statistic** - Allows you to specify the particular statistic that you wish to monitor for the @RISK output during each simulation. The comparison graphs and reports from the analysis will show the change in the value for this statistic simulation to simulation.
- **Reports** - Allows you to choose which analysis reports are generated at the end of the Sensitivity run. They include **Summary**, **Box-Whisker Plot**, **Input Graphs**, **Quick Reports**, **Percentile Graphs**, **Percent Change Graphs**, and **Tornado Graphs**. For more information on each of these reports, see **Reports** in this section.

The **Place Reports** section allows you to place your results in the active workbook, or a new workbook.

- **New Workbook** - All reports are placed in a new workbook
- **Active Workbook** - All reports are placed in the active workbook with your model

***Include
Simtable
Functions as
Inputs to
Analyze***

If a sensitivity analysis is run on worksheets which include **RiskSimtable** functions, this option causes the values specified by these functions to be included in the analysis. If **Include Simtable Functions as Inputs to Analyze** is selected, open workbooks will be scanned for RiskSimtable functions. The Advanced Sensitivity Analysis will then step through the values specified in the RiskSimtable function arguments, running a full simulation at each value. The reports generated after the run will show the sensitivity of the output statistic to both:

- 1) The variation of the inputs set up in the Advanced Sensitivity Analysis dialog and
- 2) The variation of the values from Simtable functions.

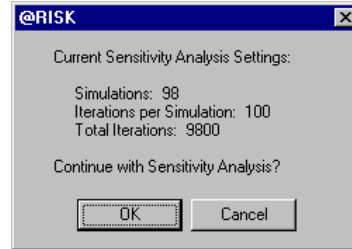
This option is especially useful if an Advanced Sensitivity Analysis is run on an @RISK model that was set up for multiple simulations. Simtable and @RISK's multiple simulation capability are often used to analyze how simulation results change when an input value is changed, by simulation, using the Simtable function. This analysis is similar to that performed by an Advanced Sensitivity Analysis. By simply selecting the option **Include Simtable Functions as Inputs to Analyze** and running an Advanced Sensitivity Analysis, multiple simulation models can get the benefit of all Advanced Sensitivity Analysis reports and graphs with no additional setup.

For more information on the RiskSimtable function, see the chapter **@RISK: Functions** in this manual.

Analyze - Advanced Sensitivity Analysis Command

Runs an Advanced Sensitivity Analysis

When the **Analyze** button is clicked, the Advanced Sensitivity Analysis prompts the user with the number of simulations, iterations per simulation, and total number of iterations. At this point, the analysis can be canceled.



When a smaller, faster analysis is desired, the Cancel button gives the user an opportunity to change the **# of Iterations** per simulation in the Simulation Settings dialog, the number of **Inputs to Analyze** or the number of values in the sequence associated with each input (that is, **# of Steps** or table items).

When an Advanced Sensitivity Analysis is run, the following actions occur for each input in the analysis:

- 1) One of the step values for the input is substituted for the existing cell value or @RISK distribution in the worksheet.
- 2) A full simulation of the model is run.
- 3) The simulation results for the tracked output **Cell to Monitor** are collected and stored.
- 4) This process is repeated until a simulation has been run for each possible step value for the input.

The results of the Sensitivity Analysis are also available in the @RISK-Results window. You can analyze them further using tools available in this window.

The Advanced Sensitivity Analysis reports include:

- **Summary**
- **Box-Whisker Plot**
- **Input Graphs**
- **Quick Reports**
- **Percentile Graph**
- **Percent Change Graph**
- **Tornado Graph**

Each of these reports is generated in Excel, either in the workbook with your model or in a new workbook. These reports are detailed in this section.

Summary

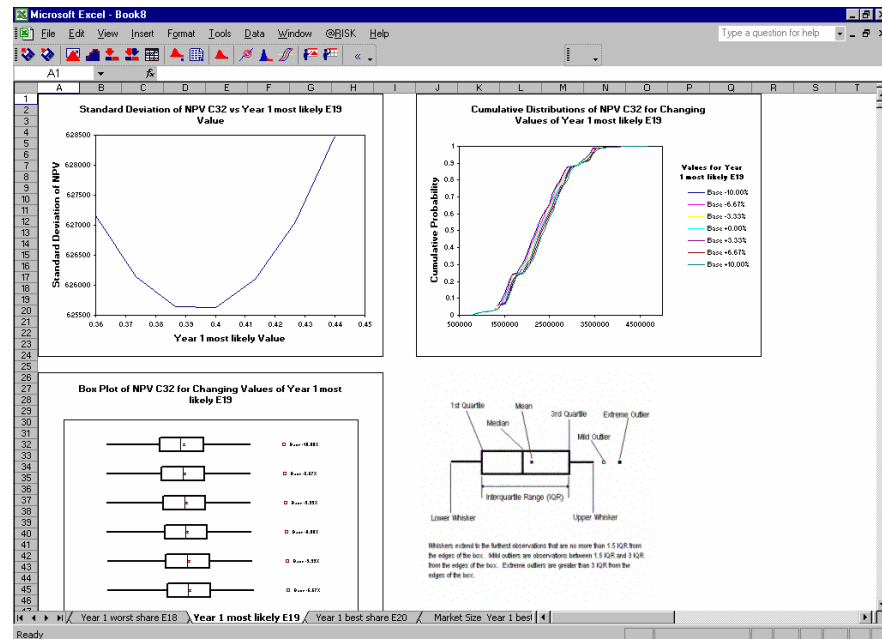
The **Summary** report describes the values assigned to the analyzed inputs, and the corresponding statistics of the monitored output: Mean, Minimum, Maximum, Mode, Standard Deviation, Variance, Kurtosis, Skewness, 5th Percentile and 95th Percentile.

Name	Book	Cell	Analysis	Value	Mean	Min	Max	Mode	Median	StdDev
Price	Hippo.xls	\$C\$16	Base -10.00%	1.960000043	2028096.641	710631.5	3658872.5	2262631.5	2000586	549163.1
Price	Hippo.xls	\$C\$16	Base -6.67%	2.053333371	2122227.689	743614.4375	3828693.5	2388576.333	2093440.25	574651.68
Price	Hippo.xls	\$C\$16	Base -3.33%	2.126666698	2216358.752	776697.3125	3996614.5	2494521.417	2186294.5	600140.27
Price	Hippo.xls	\$C\$16	Base +0.00%	2.200000048	2310489.858	809580.1875	4168335.75	2600466.25	2279148.75	625628.84
Price	Hippo.xls	\$C\$16	Base +3.33%	2.273333397	2404620.926	842563.125	4338157	2706411.25	2372002.75	651117.46
Price	Hippo.xls	\$C\$16	Base +6.67%	2.346666725	2498751.98	875546	4507978	2812356.083	2464857	676606.03
Price	Hippo.xls	\$C\$16	Base +10.00%	2.420000052	2592883.031	908528.875	4677799	2918301.083	2557711.25	702094.63
Unit Var Cost	Hippo.xls	\$C\$17	Base -10.00%	0.360000005	2361833.988	827570.875	4260965	2658254.333	2329796.25	639531.68
Unit Var Cost	Hippo.xls	\$C\$17	Base -6.67%	0.373333338	2344719.241	821574	4230088.5	2638991.667	2312913.75	634897.43
Unit Var Cost	Hippo.xls	\$C\$17	Base -3.33%	0.386666667	2327604.517	815577.0625	4199212	2619728.917	2296031.25	630263.13
Unit Var Cost	Hippo.xls	\$C\$17	Base +0.00%	0.400000006	2310489.768	809580.1875	4168335.5	2600466.25	2279148.5	625628.84
Unit Var Cost	Hippo.xls	\$C\$17	Base +3.33%	0.413333342	2293375.028	803583.3125	4137459	2581203.5	2262266	620994.55
Unit Var Cost	Hippo.xls	\$C\$17	Base +6.67%	0.426666674	2276260.294	797586.4375	4106682.5	2561940.75	2245383.5	616360.26
Unit Var Cost	Hippo.xls	\$C\$17	Base +10.00%	0.440000007	2259145.541	791589.5	4075705.75	2542678.083	2228500.75	611725.98
Interest Rate	Hippo.xls	\$C\$18	Base -10.00%	0.090000001	2366018.966	827784.0625	4275772	2690808.167	2328683.5	641458.14
Interest Rate	Hippo.xls	\$C\$18	Base -6.67%	0.093333334	2347262.421	821636.9375	4294471	2640806	2311964.25	636109.76
Interest Rate	Hippo.xls	\$C\$18	Base -3.33%	0.096666667	2328754.127	815568.4375	4203651.5	2620552.917	2295463.75	630833.74
Interest Rate	Hippo.xls	\$C\$18	Base +0.00%	0.100000001	2310489.764	809580.1875	4168335.5	2600466.25	2279148.5	625628.84
Interest Rate	Hippo.xls	\$C\$18	Base +3.33%	0.103333336	2292465.089	803669.8125	4133484.25	2580640.333	2263045.25	620493.75
Interest Rate	Hippo.xls	\$C\$18	Base +6.67%	0.106666669	2274675.961	797835.9375	4099089.25	2561070.75	2247140	615427.38
Interest Rate	Hippo.xls	\$C\$18	Base +10.00%	0.110000002	2257118.298	792077.3125	4065172.75	2566798.25	2231430	610428.40
Entrant Prob	Hippo.xls	\$C\$19	Base -10.00%	0.360000005	2365435.337	809580.1875	4168335.5	2600466.25	2376421.25	639839.22
Entrant Prob	Hippo.xls	\$C\$19	Base -6.67%	0.373333338	2347749.178	809580.1875	4168335.5	2600466.25	2332613	633678.62
Entrant Prob	Hippo.xls	\$C\$19	Base -3.33%	0.386666667	2323127.141	809580.1875	4168335.5	2301942.333	2302028	629471.22
Entrant Prob	Hippo.xls	\$C\$19	Base +0.00%	0.400000006	2310489.771	809580.1875	4168335.5	2600466.25	2279148.5	625628.84
Entrant Prob	Hippo.xls	\$C\$19	Base +3.33%	0.413333342	2290221.122	809580.1875	4168335.5	2627575.333	2264957.5	614196.38
Entrant Prob	Hippo.xls	\$C\$19	Base +6.67%	0.426666674	2274503.651	809580.1875	4168335.5	2625501.5	2248838	608135.7
Entrant Prob	Hippo.xls	\$C\$19	Base +10.00%	0.440000007	2254169.356	809580.1875	4168335.5	2625501.5	2238540.75	601908.53
Compet %age	Hippo.xls	\$E\$16	Base -10.00%	0.180000003	2396230.227	880732.8125	4201605.5	2718335.375	2367932.75	630810.83
Compet %age	Hippo.xls	\$E\$16	Base -6.67%	0.186666669	2367480.466	857015.25	4190515.5	2729184.167	2342897.25	628851.98

Input and Box-Whisker Plots

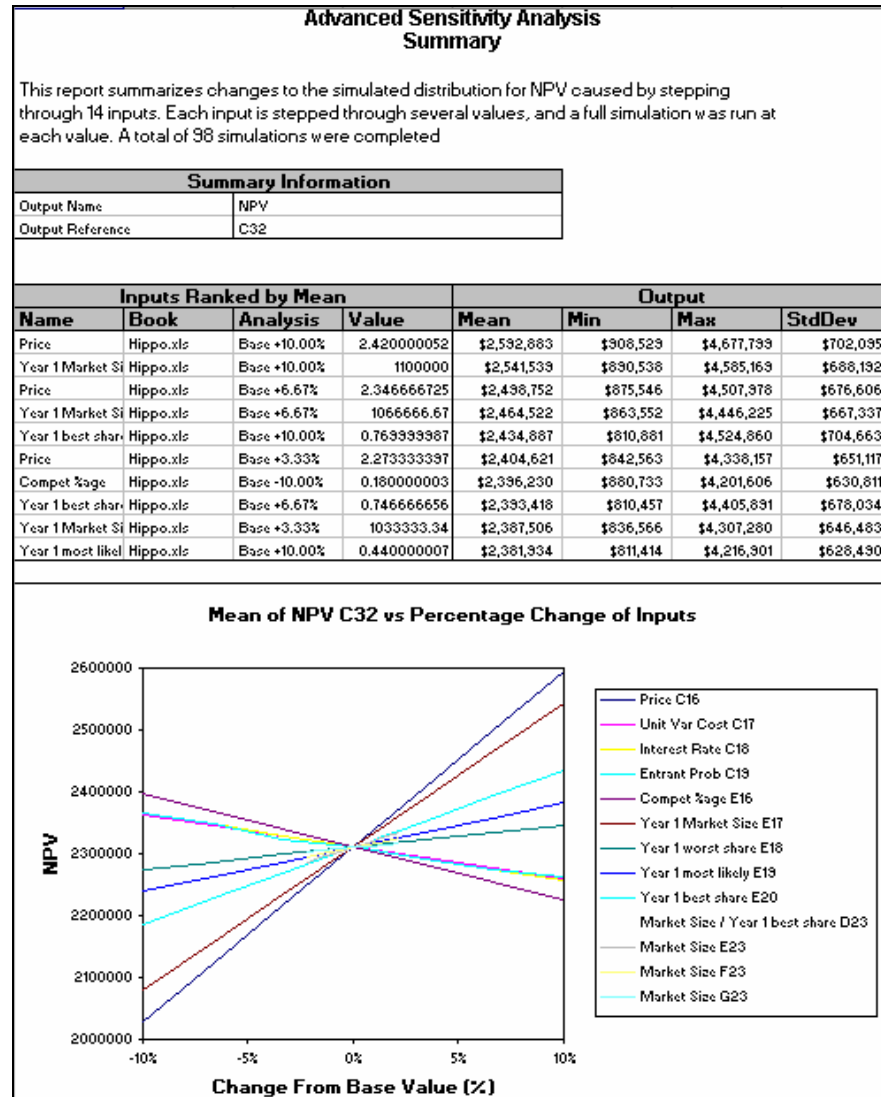
The **Input Graphs** report identifies how the tracked simulation statistic changed when simulations were run at each of the selected step values for an input. These graphs include:

- **Line Graph** – Plots the value of the tracked simulation statistic for the output against the value used for the input in each simulation. There is one point on the line graph for each simulation run when the Advanced Sensitivity Analysis was stepping across the particular input.
- **Overlaid Cumulative Distribution** – Shows the cumulative distribution for the output in each simulation run at each step value for the input. There is one cumulative distribution for each simulation run when the Advanced Sensitivity Analysis was stepping across the particular input.
- **Box-Whisker Plots** - Give an overall indication of the output distribution in each simulation run for the input, describing the mean, median, and outlying percentiles. There is one Box-Whisker plot for each simulation run when the Advanced Sensitivity Analysis was stepping across the particular input. For more information on Box-Whisker graphs, see **Stress Analysis** in this manual.



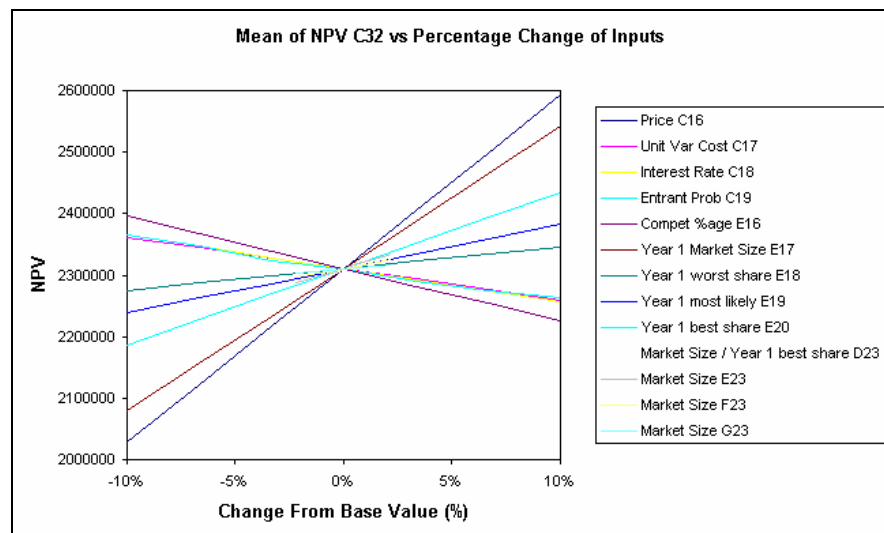
Quick Report

Quick Reports provide single page summaries of the Advanced Sensitivity Analysis as a whole or for a single input in an Advanced Sensitivity Analysis. These reports are designed to fit on a single page.



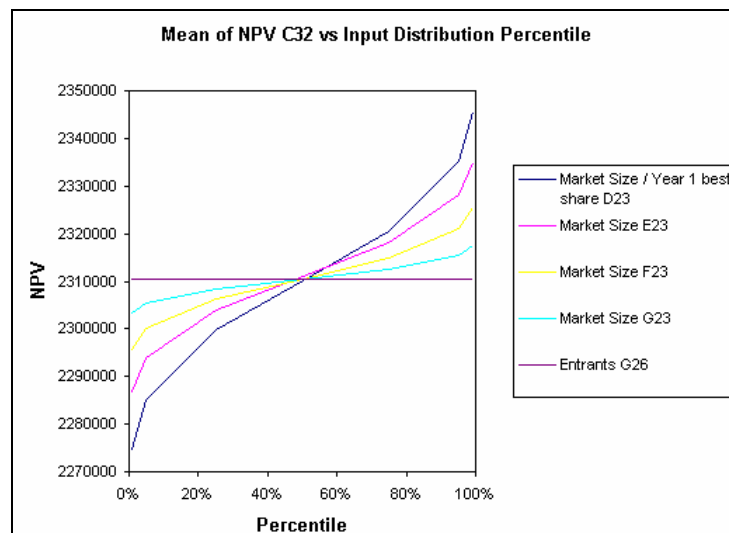
Percent Change Graph

The **Percent Change Graph** plots the **Cell To Monitor** statistic against each of the selected inputs as a Percent Change from Base. The input value on the X-axis is calculated by comparing each input value tested with the entered base value for the input.



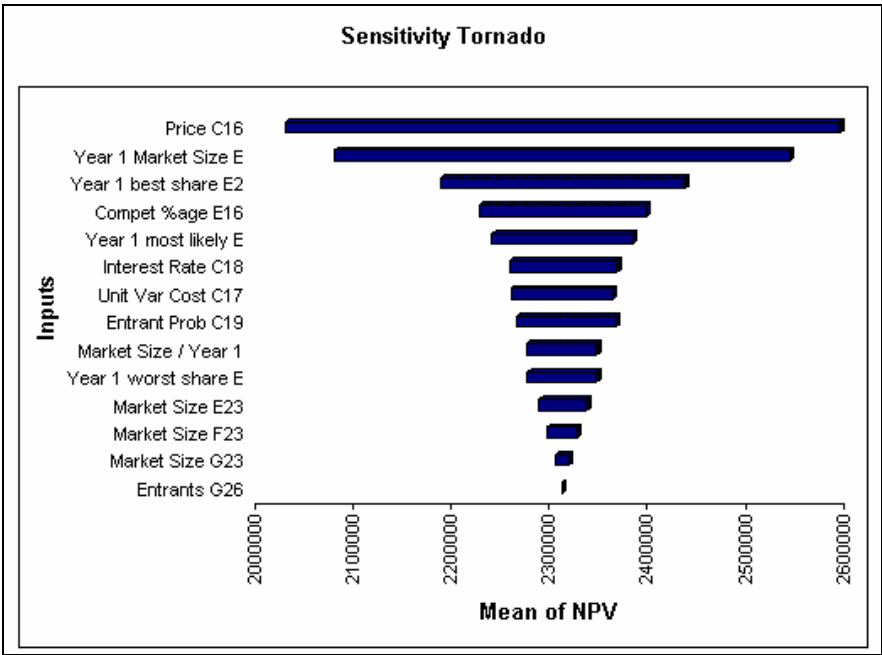
Percentile Graphs

The **Percentile Graph** plots the **Cell To Monitor** statistic against percentiles of each of the @RISK distributions that were selected for analysis with step type **Percentiles of Distribution**. Note: Only inputs that were @RISK distributions will be displayed on this graph.



Tornado

The **Tornado Graph** shows a bar for each of the inputs defined for analysis, showing the minimum and maximum values that the specified **Cell To Monitor** statistic acquires, as the values of the input vary.



Reference: @RISK Model Window Commands

File Menu

New Command

Clears all active @RISK simulation data and results

The New command clears all active @RISK simulation data from the Results and Model windows and resets @RISK settings to their default values.

Open Command

Opens a saved simulation



Open Icon

The File Open command opens a previously saved simulation data file (.RSK file) including simulation settings, all input data and graphs (with supporting fitted datasets) and simulation results including any generated graphs. For more information on the File Open command, see **File Open** in **Reference: @RISK Add-In Menu Commands**.

Save Command, Save As Command

Saves the current simulation data



Save Icon

The File menu Save and Save As commands save the current @RISK data in a .RSK file. For more information on the File Save and Save As commands, see **File Save** in **Reference: @RISK Add-In Menu Commands**.

Print Command

Prints the current graph or report

The Print command prints the active Model window graph.

Exit Command

Unloads the @RISK add-in from Excel

The File menu Exit command unloads the @RISK add-in in Excel and shuts down the supporting @RISK-Model and @RISK-Results windows. If you shut down @RISK during an Excel session, you can restart it at a later time by clicking the @RISK icon on the DecisionTools toolbar.

Edit Menu

Cut Command

Cuts the current selection

The Edit menu Cut command cuts the current selection. This data can be pasted from the Clipboard to other applications.

Copy Command

Copies @RISK reports and graphs to the Windows Clipboard

The Edit menu Copy command is used to transfer @RISK reports, graphs and fit data to the Clipboard so they can be pasted into your spreadsheet or word processor. The data to be copied is determined by the current active window and selection in @RISK. The active window is the one with its title bar highlighted.

@RISK graphs are copied to the clipboard as Windows metafiles. When placed in your spreadsheet they may be resized and annotated.

Paste Command

Pastes the current contents of the Clipboard into an @RISK window

The Edit menu Paste command is used to transfer the Clipboard contents into the current selection.

Clear Command

Removes data from the Input Data grid

The Edit menu Clear command is used to remove data from the Input data grid on a Fit Tab. Clear permanently removes data from the current selection in the input data grid, allowing new data to be entered.

Delete Tab Command

Deletes the current tab

The Delete Tab command (also selected by right-clicking on a Tab at the bottom of the Model window and selecting Delete) deletes the current tab. All open windows on the current tab are also deleted.

Note: The Model tab cannot be deleted.

Rename Tab Command

Renames the current tab

The Rename Tab command (also selected by right-clicking on a Tab at the bottom of the Model window and selecting Rename) renames the current tab.

Note: The Model tab cannot be renamed.

View Menu

Turns display of screen elements on and off

The View menu options allow you to optionally display or not display the @RISK Results window toolbars, Explorer and status bar, and customize the displayed toolbars.

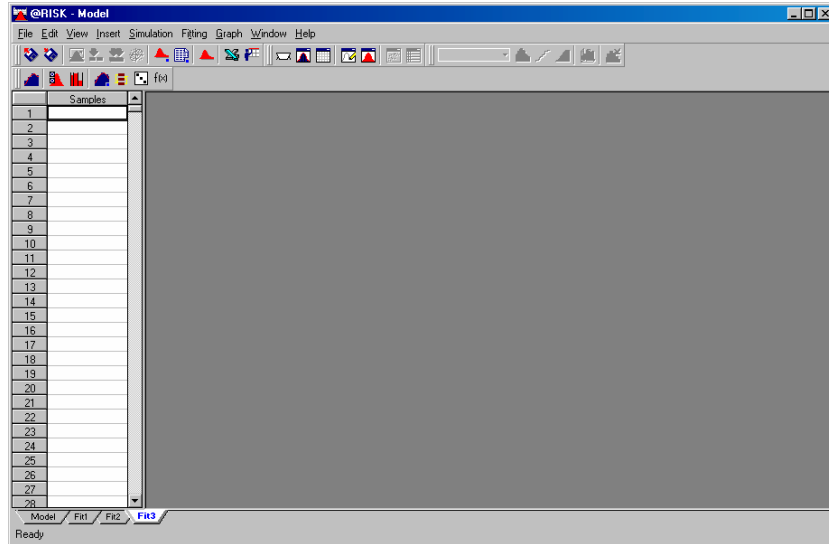
Insert Menu

Fit Tab Command

Inserts a Fit Tab in the Model window

The Insert menu Fit Tab command (or clicking the Insert Fit Tab icon) inserts a new fit tab in the Model window. A fit tab holds a data set and the distribution fitting results associated with the data set.

Fit Tab



When initially inserted, a fit tab contains an empty Input Data grid on the left where a data set to be fit can be entered. As fitting is performed, Fit Results and Summary windows are displayed in the other part of the fit tab.

To learn about the commands used to fit probability distributions to a data set contained on a fit tab, see **Fitting Menu Commands** in this Reference section.

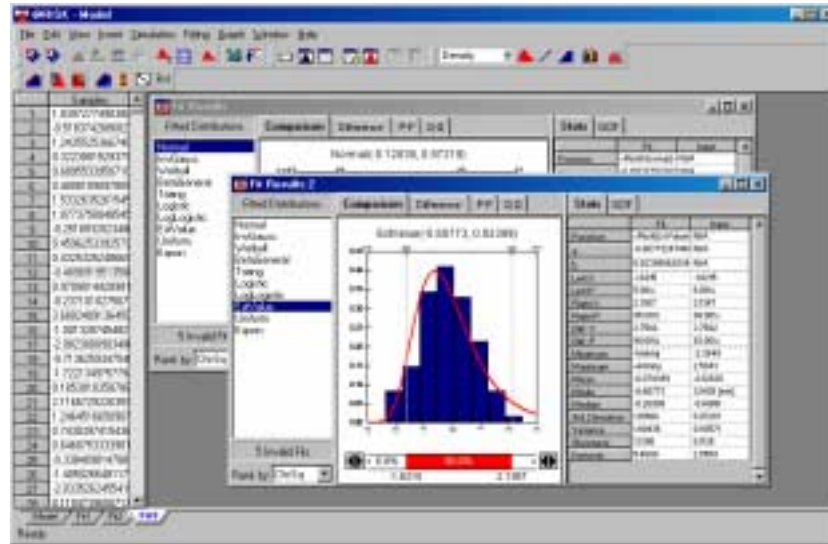
Note: One data set can be added to a single fit tab. To fit additional data sets, insert additional fit tabs.

Fit Results Window Command

Inserts a Fit Results Window in the Model window

The Insert menu Fit Results Window command (or clicking the Insert Fit Results Window icon) inserts a Fit Results window on a fit tab in the Model window. A Fit Results window displays the results of the most recent fit performed on the data set on the fit tab where the Fit Results window is placed.

Results Window



When you run a fit, a new Fit Result window is automatically created for you if one does not exist. Multiple Results windows can be displayed for the current fit results. This allows different fitted distributions to be displayed simultaneously and compared.

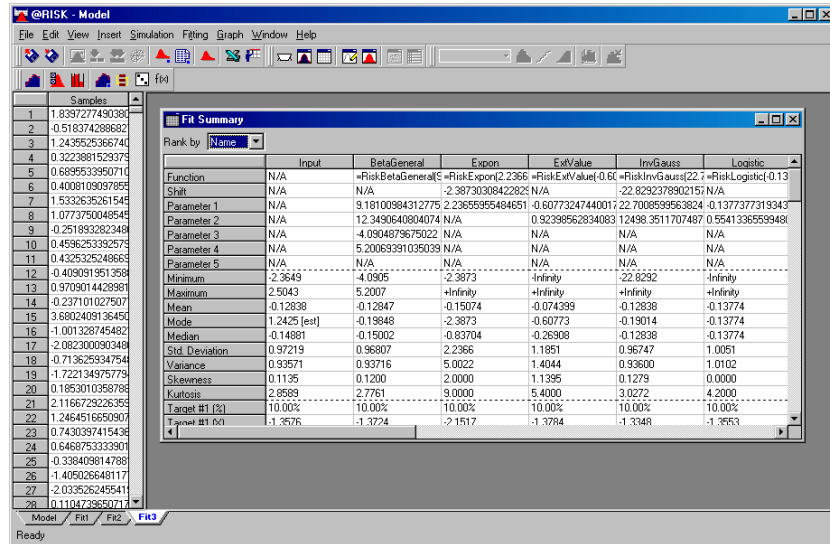
To learn about the contents of the Fit Results window and the commands used for fitting probability distributions to data, see the **Fitting Menu: Run Fit Now Command** in this Reference section.

Fit Summary Window Command

Inserts a Fit Summary window in the Model window

The Insert menu Fit Summary Window command (or clicking the Insert Fit Summary Window icon) inserts a Fit Summary window on a fit tab in the Model window. A Fit Summary window displays a report of the results of the most recent fit performed on the data set shown on the active fit tab.

Fit Summary Window



Rank by	Name	Input	BetaGeneral	Expon	ExtValue	InvGauss	Logistic
Function	N/A	+RiskBetaGeneral(S	+RiskExpon(2.2366	+RiskExtValue(0.60	+RiskInvGauss(22.7	+RiskLogistic(0.13	
Shift	N/A	N/A	-2.38730308422825	N/A			
Parameter 1	N/A	9.18100984312775	2.23655955484651	-0.60773247440017	22.7008599563824	-0.1377377319343	
Parameter 2	N/A	12.3490640804074	N/A	0.92398562834083	12498.3511707487	0.5541336559948	
Parameter 3	N/A	-4.0904879675022	N/A	N/A	N/A	N/A	
Parameter 4	N/A	5.20063391035039	N/A	N/A	N/A	N/A	
Parameter 5	N/A	N/A	N/A	N/A	N/A	N/A	
Minimum	-2.3649	4.0905	-2.3873	-Infinity	-22.8292	-Infinity	
Maximum	2.5043	5.2007	-Infinity	-Infinity	-Infinity	-Infinity	
Mean	-0.12838	-0.12847	-0.15074	-0.074399	-0.12838	-0.13774	
Mode	1.2425 [est]	-0.19848	-2.3873	-0.60773	-0.19014	-0.13774	
Median	-0.14881	-0.15002	-0.83704	-0.26908	-0.12838	-0.13774	
Std. Deviation	0.97219	0.96807	2.2366	1.1851	0.96747	1.0051	
Variance	0.93571	0.93716	5.0022	1.4044	0.93600	1.0102	
Skewness	0.1135	0.1200	2.0000	1.1395	0.1279	0.0000	
Kurtosis	2.9889	-2.7761	9.0000	5.4000	3.0272	4.2000	
Target #1 [%]	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	
Target #1 [Std]	-1.3576	-1.3724	-2.1517	-1.3794	-1.3348	-1.3553	

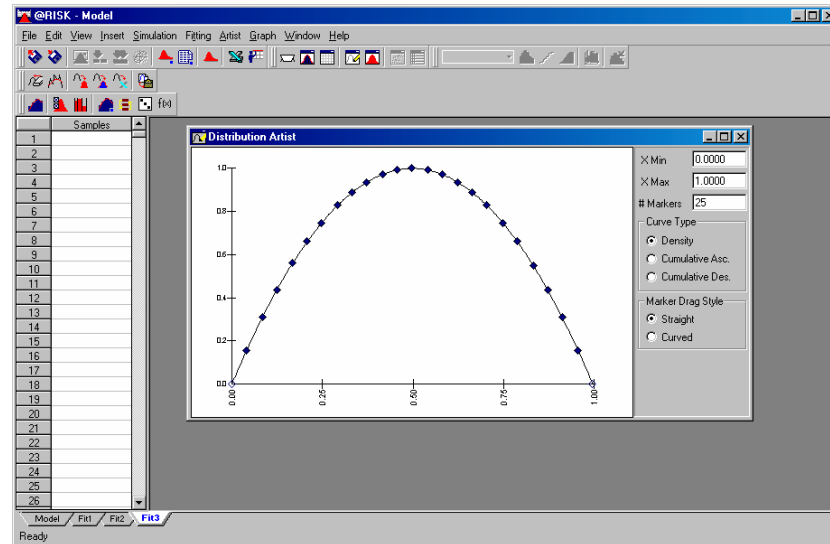
A Fit Summary window displays all relevant statistics on the results of a fit. For more information on the contents of the Fit Summary window, see **Fit Results** under **Fitting Menu: Run Fit Now Command** in this section.

Artist Window Command

Inserts an Artist window in the Model window

The Insert menu Artist Window command (or clicking the Insert Artist Window icon) inserts a Artist window in the Model window. An Artist window allows a free-form curve to be drawn, which can then be used to define a probability distribution.

Artist Window



To learn about the commands used to draw curves in the Artist window, see **Artist Menu Commands** in this Reference section.

Distribution Window Command

Inserts a Distribution window in the Model window

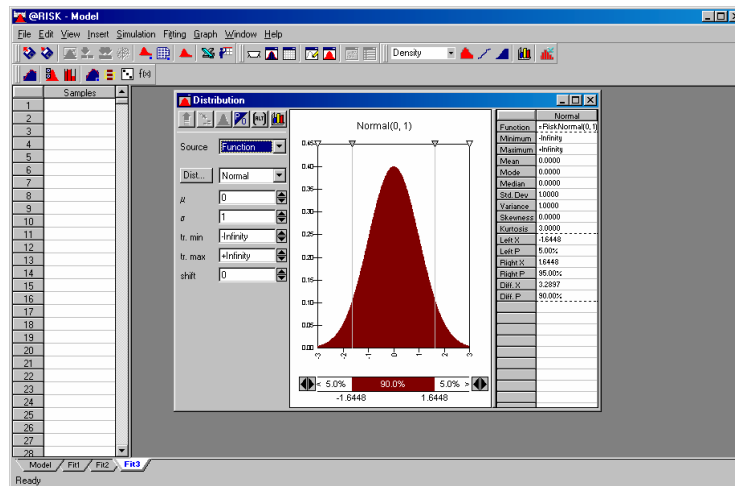
The Insert menu Distribution Window command (or clicking the Insert Distribution Window icon) inserts a Distribution window in the Model window. Distribution windows can be used at any time to preview a probability distribution, input and fit results.

A Distribution window displays either a:

- 1) **Graph of a theoretical distribution whose parameters are entered in the distribution window.**
- 2) **Graph of input data contained in the Input data grid on a fit tab.**
- 3) **Graph of a distribution function generated by a fit.**

An overlay graph may also be placed on a distribution graph in the Distribution window. This overlay can come from any of the three sources listed above.

Distribution Window



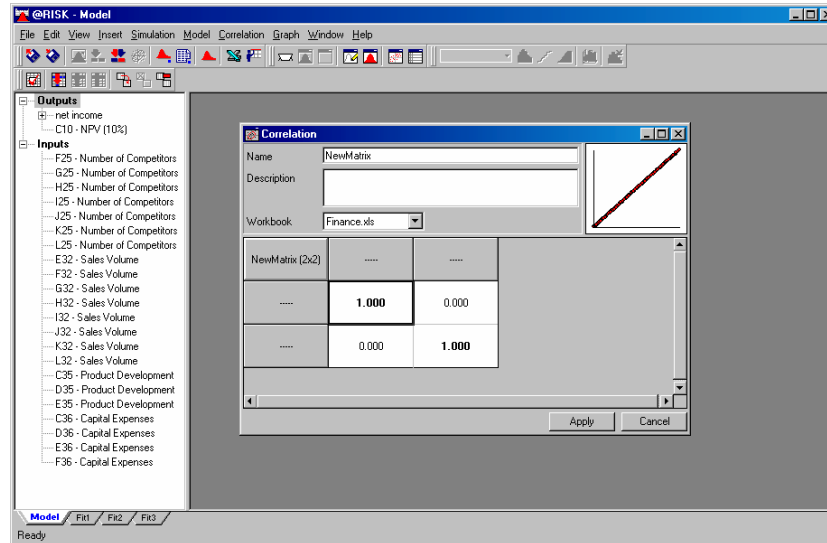
Contents of the Distribution Window

The contents of the Distribution window are similar to the Define Distribution window which is either popped up over Excel or displayed when an input is graphed from the Outputs and Inputs. The Define Distribution window contains Excel cell formula information which a Distribution window does not. Otherwise, the two windows are nearly identical. For information on using all elements of the Distribution window (except those listed below) see the **Define Distribution Command** in the **@RISK Add-In Menu** section of this Reference chapter.

Correlation Window Command

Inserts a Correlation window in the Model window

The Insert menu Correlation Window command (or clicking the Insert Correlation Window icon) inserts a blank Correlation window in the Model window. A Correlation window allows you to correlate input distributions in your model by entering a matrix of correlation coefficients. By dragging input distributions from the Explorer list onto a blank matrix you can select which inputs you wish to correlate in a matrix.



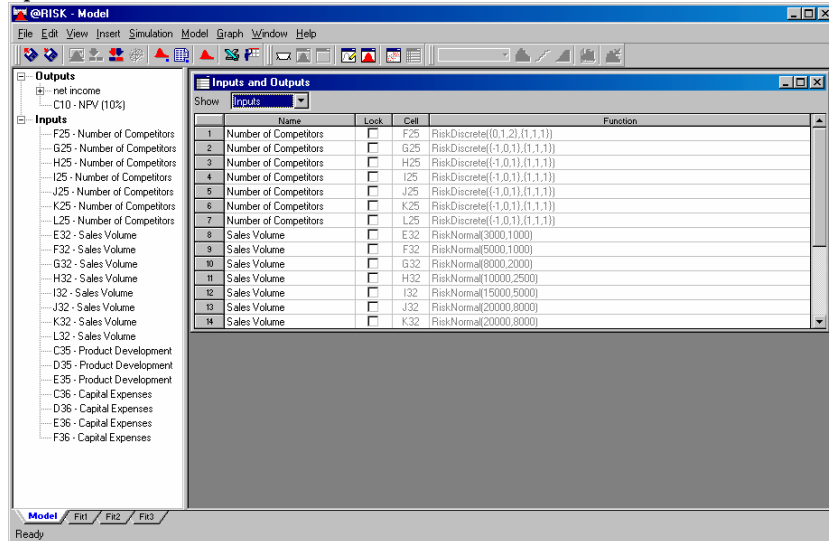
Any number of correlation matrices may be specified for your model. Each matrix entered is listed in the Correlations section of the Explorer list on the Model tab. At any time you can edit an existing matrix by right-clicking on the matrix name in the Explorer and selecting the Edit Correlation Matrix command.

To learn more about setting up and editing correlation matrices, see the **Correlations Menu Commands** in this Reference section.

Inputs and Outputs Window Command

Inserts an Inputs and Outputs Window in the Model window

The Insert menu Inputs and Outputs Window command (or clicking the Insert Inputs and Outputs Window icon) inserts an Inputs and Outputs in the Model window. An Inputs and Outputs Window displays a summary of all inputs and outputs currently defined in the open worksheets in Excel.



The Inputs and Outputs window displays the location and definition of all @RISK distribution functions in your open worksheets. In this window you can change the name of any input or output, lock it to keep it from sampling or select to have samples collected for a distribution (when the Simulation Settings option for **Collect Distribution Samples** is set to **Inputs Marked with Collect**).

Simulation Menu

Settings Command

Changes the settings which control the simulations performed by @RISK



***Simulation
Settings Icon***

The Simulation menu Settings command affects the tasks performed during a simulation. For more information on the available simulation settings, see the **Simulation menu Settings Command** in the section **@RISK Add-In Menu Commands** in this chapter.

Start Command

Starts a Simulation

The Simulation menu Start command (or clicking the Simulate icon) starts a simulation using the current settings.

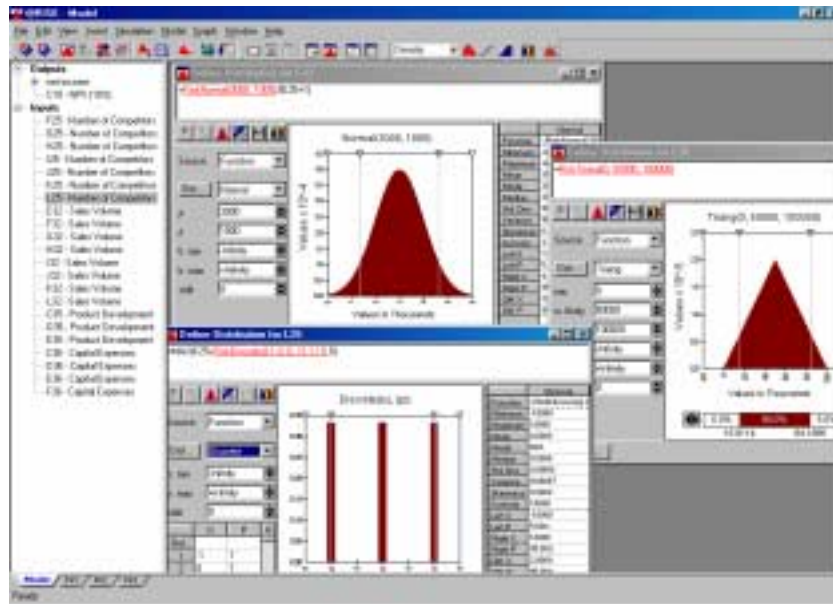
Model Menu

The Model menu commands allow the entering and editing of input distribution functions, outputs and correlation matrices that have been entered in an @RISK model in Excel. The Model menu commands are also displayed when an output, input or correlation matrix is right-clicked in the Explorer list on the Model tab in the Model window.

Define Distribution Command

Displays the @RISK Define Distribution window with a graph of the selected input distribution displayed

The Graph menu Define Distribution command displays the input(s) currently selected in the Explorer list on the Model tab in the Define Distribution window(s). Once displayed, each selected input distribution can be edited or deleted and new distributions can be added to the displayed formula.



For more information on using the @RISK Define Distribution window, see the **@RISK Add-In Model Menu Define Distribution Command** in this Reference chapter.

Function Properties Command

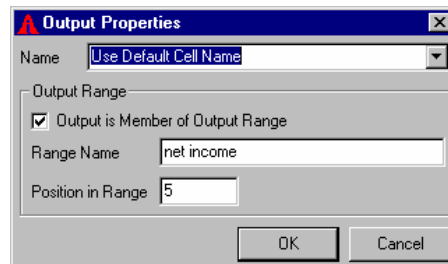
Displays the current properties of an @RISK input distribution or output

The Model menu Function Properties command displays the current property settings for an @RISK input distribution or output.

Properties include **name** (both inputs and outputs), **collect and lock settings** (inputs only), and **output range settings** (outputs only).

Once specified, function properties for probability distributions are added to distribution functions in Excel using distribution property functions. For more information on distribution property functions, see **Distribution Property Functions** in the **Reference: @RISK Functions** section of this chapter.

Function Properties for Outputs



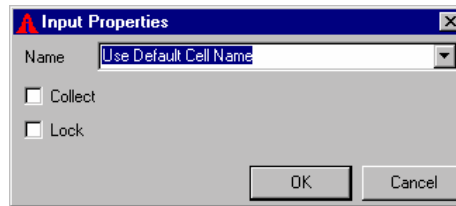
The properties available for outputs in an @RISK model include:

- **Name.** Selects the name to use to identify the output in graphs and reports. The **Use Default Cell Name** entry specifies that @RISK will automatically generate a name for the output using row and column headings it identifies in your worksheet.
- **Output is Member of Output Range.** Selects whether or not the output cell is part of an output range. Output ranges are groups of related cells (such as Profit by Year).
- **Range Name.** If output is part of an output range, specifies the name of the range.
- **Position in Range.** If output is part of an output range, specifies the position of the cell in the range, where cells are ordered from 1 to the total number of cells in the range.

Each property is entered as an argument to the RiskOutput function which identifies the output cell in Excel. Properties can be specified or changed by adding arguments directly to the RiskOutput function instead of using the Function Properties dialog.

Function Properties for Inputs

For more information on the RiskOutput function, see **RiskOutput** in the **Reference: @RISK Functions** section of this chapter.



The properties available for inputs in an @RISK model include:

- **Name.** Selects the name to use to identify the input in graphs and reports. The **Use Default Cell Name** entry specifies that @RISK will automatically generate a name for the input using row and column headings it identifies in your worksheet.
- **Collect.** Specifies whether or not samples will be collected for the distribution during a simulation when the **Inputs Marked with Collect** option is selected for **Collect Distribution Samples** in the Simulation Settings dialog.
- **Lock.** Specifies whether or not the distribution will be sampled during a simulation. If Lock is selected, the distribution will return its expected value during a simulation. This allows you to temporarily remove a probability distribution from a simulation to test the impacts of the removal on simulation results.

Each property is entered as a distribution property function which is used as an argument to the distribution function in Excel. Properties can also be specified or changed by adding distribution property functions directly to the distribution function, instead of using the Function Properties dialog. For more information on distribution property functions, see **Distribution Property Functions** in the **Reference: @RISK Functions** section of this chapter.

Remove Functions Command

Removes @RISK functions from selected cells or all worksheets in Excel

The Remove Functions command removes all @RISK functions from either the cells currently selected in the Explorer list in the Model window or from all open worksheets in Excel.

Correlate Distributions Command

Defines or edits correlations between probability distributions in the formulas of the selected cells



**Correlate
Distributions
Icon**

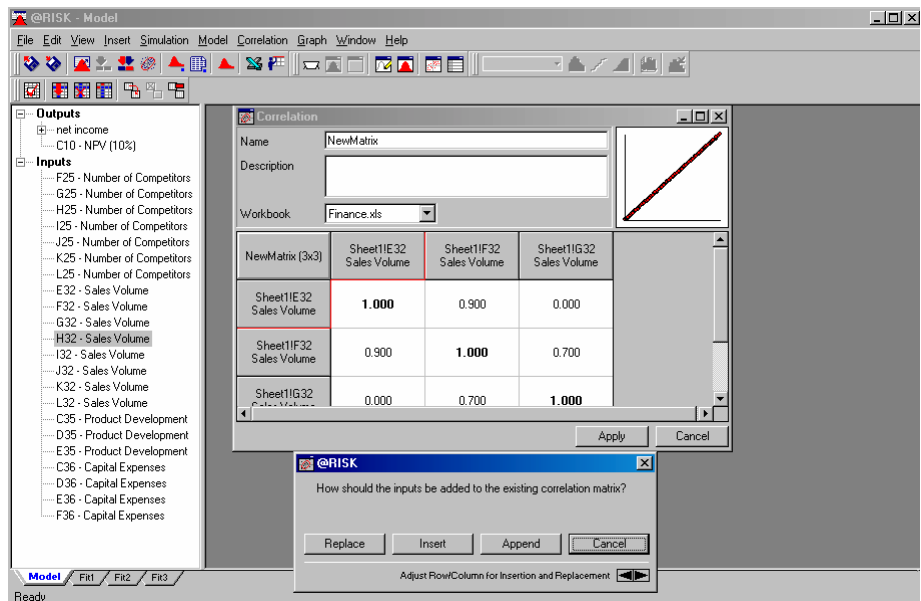
The Model menu Correlate Distributions command allows the samples of input probability distributions to be correlated. When the Correlate Distributions command is selected (or the Correlate Distributions icon is clicked), a matrix is displayed in the Model window which includes a row and column for each probability distribution currently selected in the Explorer list. Correlation coefficients between the probability distributions can be entered using this matrix.

Sales_Correlations (4x4)	Sheet1!E32 Sales Volume	Sheet1!F32 Sales Volume	Sheet1!G32 Sales Volume	Sheet1!H32 Sales Volume
Sheet1!E32 Sales Volume	1.000	0.500	0.000	0.000
Sheet1!F32 Sales Volume	0.500	1.000	0.000	0.000
Sheet1!G32 Sales Volume	0.000	0.000	1.000	0.000
Sheet1!H32 Sales Volume	0.000	0.000	0.000	1.000

Two input distributions are correlated when their samples should be "related" — that is, the value sampled for one distribution should affect the value sampled for the other. This correlation is necessary when, in reality, two input variables move to some degree in tandem. For example, imagine a model with two input distributions — Interest Rate and Housing Starts. These two inputs are related, as the value sampled for Housing Starts depends on the value sampled for Interest Rate. A high Interest Rate would tend to cause a low value for Housing Starts, and conversely a low Interest Rate would tend to cause a high value for Housing Starts. If this correlation were not accounted for in sampling, some iterations of the simulation would reflect non-sensical conditions that could not occur in reality — such as a high Interest Rate and a high value for Housing Starts.

Adding Inputs to a Pre-Existing Matrix

If the Correlate Distributions command is selected and the active window is a pre-existing correlation matrix, you have the option to add each probability distribution currently selected in the Explorer list to the current matrix. When distributions are added to a pre-existing matrix, the following options are displayed:



Select **Replace** to replace the inputs starting at the highlighted position in the matrix with the new inputs, while maintaining the entered coefficients. Select **Insert** to add new row/columns for the inputs at the current location. Select **Append** to add the inputs as new row/columns after the last row/column in the matrix. Clicking **Adjust Row/Column for Insertion and Replacement** moves the highlighted row/column through the matrix.

A single input may be added to a matrix by holding down the mouse button on an input in the Explorer and dragging the input onto a correlation matrix. The input is added at the location highlighted as you move your mouse across the matrix. **Replace, Insert and Append** options are also shown when dragging a new input onto a matrix.

Entering Correlation Coefficients

Correlations between input distributions are entered into a matrix displayed when the Correlate Distributions command is selected (or the Correlate Distributions icon is clicked). The rows and columns of this matrix are labeled with each of the input distributions in the currently selected cells. Any specific cell in the matrix specifies the correlation coefficient between the two input distributions identified by the row and column of the cell.

Correlation coefficients range in value between -1 and 1. A value of 0 indicates there is no correlation between the two variables — i.e., they are independent. A value of 1 is a complete positive correlation between the two variables — i.e., when the value sampled for one input is "high", the value sampled for the second will also be "high". A value of -1 is a complete inverse correlation between the two variables — i.e., when the value sampled for one input is "high", the value sampled for the second will be "low". Coefficient values in between, such as -.5 or .5, specify a partial correlation. For example, a coefficient of .5 specifies that when the value sampled for one input is "high", the value sampled for the second will tend to, but not always, be "high".

Correlations may be entered between any input distributions. A distribution may be correlated with many other input distributions. Often your correlation coefficients will be calculated from actual historical data on which you are basing the distribution functions in your model.

Entering Correlation Coefficients

To enter correlations between your input distributions:

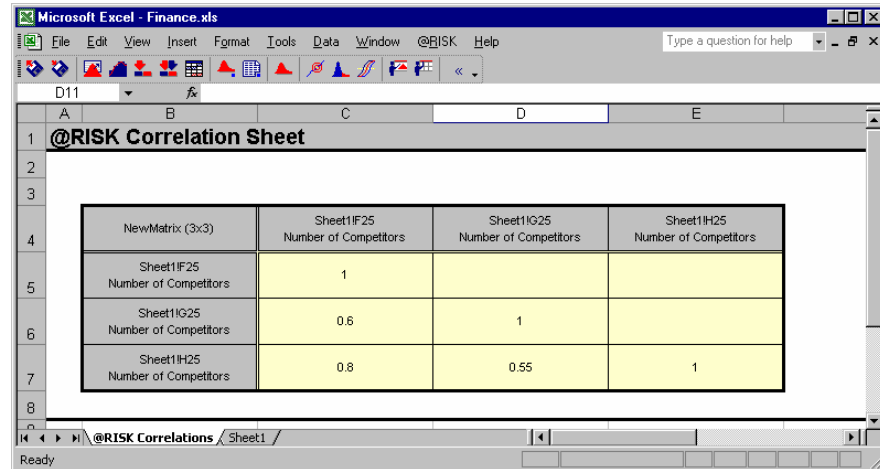
- 1) Select the inputs in the Explorer list that you wish to correlate. Hold the <Ctrl> key down as you select multiple inputs.
- 2) Click the Correlate Distributions icon, or select the Correlate Distributions command from the right-click pop-up menu in the Explorer.
- 3) Scroll the matrix and highlight the cell that represents the intersection of the row representing one distribution and the column representing the second. Type in the desired coefficient value.
- 4) Move to other cells as needed to enter additional coefficients.
- 5) When done, click Apply to enter the matrix in Excel and add RiskCorrmat functions to the input distribution functions in the matrix.

To add distributions to an existing matrix (or a blank matrix created with the Insert menu Correlation Window command):

- 1) Drag input distributions from the Explorer list onto an existing matrix.
- 2) Edit the correlation coefficients in the matrix as described in the prior section.

Note: There are two possible cells where the correlation between any two inputs may be entered (row of the first and column of the second, or column of the first and row of the second). You can use either cell — as you enter a coefficient value in one it is automatically entered in the second cell.

Correlation Matrix Displayed in Excel



NewMatrix (3x3)	Sheet1!F25 Number of Competitors	Sheet1!G25 Number of Competitors	Sheet1!H25 Number of Competitors
Sheet1!F25 Number of Competitors	1		
Sheet1!G25 Number of Competitors	0.6	1	
Sheet1!H25 Number of Competitors	0.8	0.55	1

When Apply is clicked from a correlation matrix window the entered matrix is added to a worksheet in Excel, and RiskCorrmat functions that reference the matrix are added to the input distributions contained in the matrix. Correlation coefficients may be changed in this Excel matrix, as well as in the matrix displayed in the model window. New inputs, however, cannot be added to the matrix displayed in Excel. To add new inputs to a matrix, edit the matrix in the Model window.

For more information on entering and editing correlation matrices, see the **Model Window Correlation Menu Commands** in this Reference section.

Understanding Rank Order Correlation Coefficient Values

The correlation of input distributions in @RISK is based on the rank order correlations. The rank order correlation coefficient was developed by C. Spearman in the early 1900's. It is calculated using rankings of values, not actual values themselves (as is the linear correlation coefficient). A values "rank" is determined by its position within the min-max range of possible values for the variable.

@RISK generates rank-correlated pairs of sampled values in a two step process. First, a set of randomly distributed "rank scores" is generated for each variable. If 100 iterations are to be run, for example, 100 scores are generated for each variable. (Rank scores are simply values of varying magnitude between a minimum and maximum. @RISK uses van der Waerden scores based on the inverse function of the normal distribution). These rank scores are then rearranged to give pairs of scores which generate the desired rank correlation coefficient. For each iteration there is a pair of scores, with one score for each variable.

In the second step, a set of random numbers (between 0 and 1) to be used in sampling is generated for each variable. Again, if 100 iterations are to be run, 100 random numbers are generated for each variable. These random numbers are then ranked smallest to largest.

For each variable, the smallest random number is then used in the iteration with the smallest rank score, the second smallest random number is used in the iteration with the second smallest rank score and so on. This ordering based on ranking continues for all random numbers, up to the point where the largest random number is used in the iteration with the largest rank score.

In @RISK this process of rearranging random numbers happens prior to simulation. It results in a set of paired random numbers that can be used in sampling values from the correlated distributions in each iteration of the simulation.

This method of correlation is known as a "distribution-free" approach because any distribution types may be correlated. Although the samples drawn for the two distributions are correlated, the integrity of the original distributions is maintained. The resulting samples for each distribution reflect the input distribution function from which they were drawn.

Specifying Correlations With Functions

Correlations between input distributions may also be entered directly in your worksheet using the CORRMAT function. The correlations specified using this function are identical to those entered when Apply is clicked from the Correlation Matrix window.

For more information on using these functions to enter correlations, see the description of these functions in the **Reference: @RISK Functions** section of this chapter.

For further information on working with correlation matrices, see the **Correlation Menu Commands** in this section.

Delete Correlation Matrix Command

Deletes the selected correlation matrix

The Model menu Delete Correlation Matrix command deletes the selected correlation matrix. All RiskCorrmat functions will be removed from distribution functions used in the matrix and the correlation matrix displayed in Excel will be deleted.

Find Outputs and Inputs Command

Scans open worksheets, identifies all @RISK functions and updates the Explorer list in the Model window

The Model menu Find Outputs and Inputs finds all @RISK distributions in all open worksheets in Excel. Use this command to update all entries in the Explorer list in the Model window. If you are entering probability distributions directly in formulas in Excel use this command to keep your Explorer list up to date. @RISK also checks that Model window information for individual cells is up to date when an input or output is edited using the Model menu Define Distribution or Edit Output command.

Note: When Apply is clicked from an open @RISK Define Distribution window, the cell formula (including any @RISK distribution functions) that is shown in the window is placed in the specified cell. This formula will overwrite the existing formula in the cell, even if the formula in the cell has been changed in Excel while the @RISK Define Distribution window for the cell is open.

Correlation Menu

The Correlation menu commands allow you to edit correlation matrices and create new instances of existing matrices. There are also options in the Correlation Window itself for identifying and describing an entered matrix. These options are also described in this section.

Check Matrix Consistency Command

Checks the consistency of the active correlation matrix

The Model menu Check Matrix Consistency command checks if the entered matrix in the active correlation window is valid. @RISK can correct any invalid matrix and generate the closest valid matrix to the entered invalid one.

Invalid Correlation Matrices

An invalid matrix specifies inconsistent simultaneous relationships between three or more inputs. It is quite easy to make a correlation matrix which is invalid. A simple example is: correlate input **A** and **B** with a coefficient of +1, **B** and **C** with a coefficient of +1, and **C** and **A** with a coefficient of -1. This example is clearly illegal, but invalid matrices are not always this obvious. In general, a matrix is valid only if it is *positive semi-definite*. A positive semi-definite matrix has eigenvalues which are all greater than or equal to zero, and at least one eigenvalue that is greater than zero.

If @RISK determines you have an invalid matrix when the Check Matrix Consistency command is selected, it will give you the option of letting @RISK generate the closest valid matrix to the entered invalid one. @RISK follows these steps to modify a matrix:

- 1) Finds the smallest eigenvalue (E_0)
- 2) "Shifts" the eigenvalues so that the smallest eigenvalue equals zero by adding the product of $-E_0$ and the identity matrix (**I**) to the correlation matrix (**C**): $C' = C - E_0I$.
- 3) Divides the new matrix by $1 - E_0$ so that the diagonal terms equal:
 $C'' = (1/1-E_0)C'$

This new matrix is positive semi-definite, and therefore, valid. It is important to check the new valid matrix to ensure that its correlation coefficients accurately reflect your knowledge of the correlation between the inputs included in the matrix.

Note: A correlation matrix entered in the Correlation window is automatically checked for consistency when the Apply button is clicked, prior to entering the matrix in Excel and adding RiskCorrmat functions for each input in the matrix.

Insert Row/Column Command

Inserts a row and column in the active correlation matrix

The Model menu Insert Row/Column command inserts a new row and column in the active correlation matrix. A new column will be placed in the matrix at the cursor location, shifting existing columns to the right. A new row is also added at the same position as the added column, shifting existing rows down.

Once a new row/column is added to a matrix, a new input can be added to the matrix by dragging an input from the Explorer list onto the new row. Select **Replace** from the displayed dialog to assign the new input to the new row/column.

Delete Selected Row/Column(s) Command

Deletes a row and column in the active correlation matrix

The Model menu Delete Selected Row/Column(s) command deletes the selected rows and columns from the active correlation matrix. This command is only available when one or more rows or columns are selected in the matrix by clicking on row or column headings.

Detach Selected Input(s) Command

Removes the selected input(s) from the active correlation matrix

The Model menu Detach Selected Input(s) command removes the selected input(s) from the active correlation matrix. This command is only available when one or more rows or columns are selected in the matrix by clicking on row or column headings. When inputs are detached, only the inputs are removed – the coefficients specified in the matrix remain.

Instance Commands

An instance is a new copy of an existing matrix that can be used to correlate a new set of inputs. Each instance contains the same set of correlation coefficients; however, the inputs that are correlated with each instance are different. This allows you to easily set up groups of similarly correlated variables without repeating the entry of the same matrix over and over. In addition, when a correlation coefficient is edited in any instance of a matrix, it is automatically changed in all instances.

Each instance of a matrix has a name. Instances can be deleted or renamed at any time.

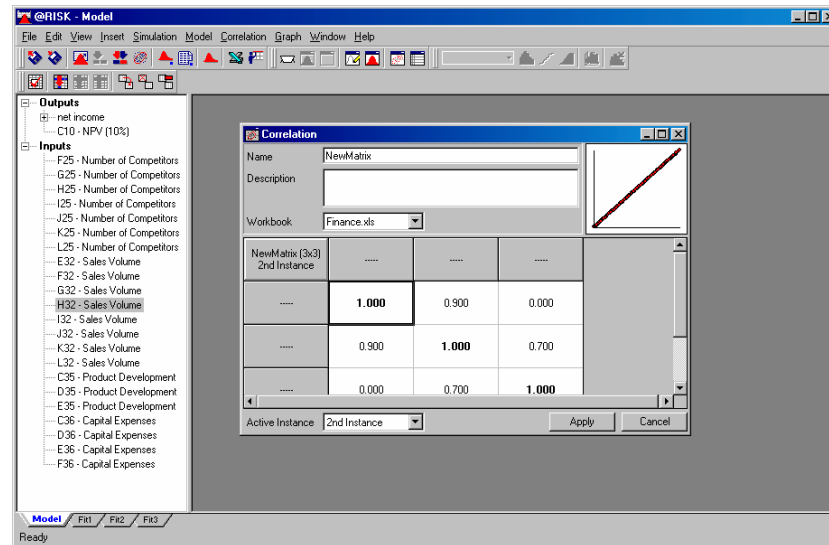
Instance is a third optional argument to the RiskCorrmat function. This allows you to easily specify instances when entering correlation matrices and RiskCorrmat functions directly in Excel. For more information on the RiskCorrmat function and the Instance argument, see RiskCorrmat in the **Reference: @RISK Functions** section of this chapter.

Note: When a correlation matrix with multiple instances is created in the Model window and displayed in Excel, only the inputs for the first instance are shown in the headings of the matrix added to the @RISK Correlation sheet.

Create New Instance Command

Creates a new instance of the active correlation matrix

The Model menu Create New Instance command creates a new instance of the active correlation matrix. Prior to creating a new instance, you must give it a name.



When a new instance is created, a new copy of the active matrix is made with no inputs attached to the rows and columns of the matrix. To add inputs to the new instance:

- **Simply drag input distributions from the Explorer list onto the new matrix.**

To view a different instance of the matrix:

- **Switch the Active Instance entry at the bottom of the correlation window.**

Delete Instance Command

Deletes the current instance of the active correlation matrix

The Model menu Delete Instance command deletes the current instance of the active correlation matrix. Correlations are removed for all inputs included in the instance.

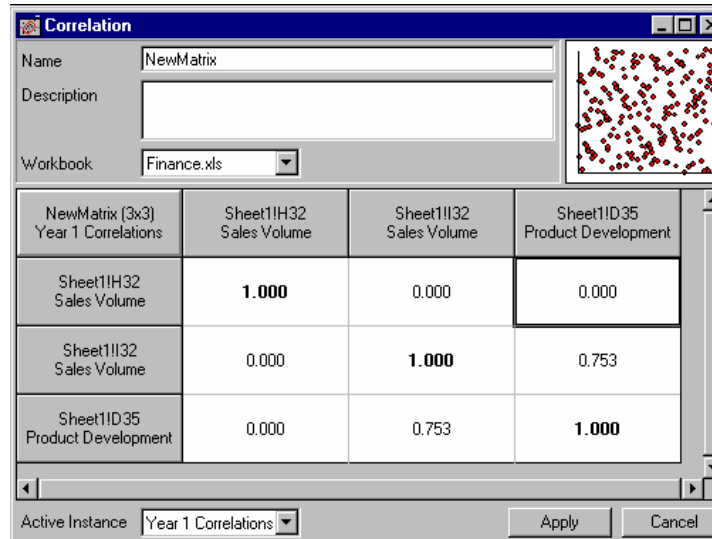
Rename Instance Command

Renames the current instance of the active correlation matrix

The Model menu Rename Instance command renames the current instance of the active correlation matrix. The new name is shown in the Active Instance entry at the bottom of the correlation window.

Correlation Window Options

The Correlation Window contains entries for **Name**, identifying the matrix in the window, **Description**, describing the matrix in the window, and **Workbook**, specifying the location in Excel for the matrix entered. This information is used when the entered correlation matrix is added to Excel when the Apply button is clicked.



The screenshot shows the 'Correlation' dialog box. It has fields for 'Name' (NewMatrix), 'Description' (empty), and 'Workbook' (Finance.xls). To the right is a small scatter plot. Below these fields is a 3x3 correlation matrix table. The table has headers: 'NewMatrix (3x3) Year 1 Correlations', 'Sheet1IH32 Sales Volume', 'Sheet1II32 Sales Volume', and 'Sheet1ID35 Product Development'. The diagonal elements are all 1.000. The off-diagonal elements are 0.000 for the first two rows, and 0.753 for the third row against the first two columns.

NewMatrix (3x3) Year 1 Correlations	Sheet1IH32 Sales Volume	Sheet1II32 Sales Volume	Sheet1ID35 Product Development
Sheet1IH32 Sales Volume	1.000	0.000	0.000
Sheet1II32 Sales Volume	0.000	1.000	0.753
Sheet1ID35 Product Development	0.000	0.753	1.000

At the bottom, there is an 'Active Instance' dropdown set to 'Year 1 Correlations', and 'Apply' and 'Cancel' buttons.

The entries in the Correlation window include:

- **Name.** Specifies the Name of the matrix which will be used to identify the matrix in the RiskCorrmat functions that are created for each input distribution included in the matrix. This name must be a valid Excel range name.
- **Description.** Gives a description of the correlations included in the matrix. This entry is optional.
- **Workbook.** Specifies the name of the workbook where the @RISK Correlations sheet will be placed. By default the sheet will be placed in the same workbook where your inputs are located.

How a Correlation Matrix is Added to Your Model in Excel

When you enter a correlation matrix in the Model Window and click **Apply**, the following events take place:

- 1) The matrix is added to a worksheet named **@RISK Correlations** located in the workbook specified in the **Workbook** entry in the Correlation window. This matrix in Excel is identified with an Excel range name that has the name specified in the **Name** entry in the Correlation window. The **Description** entry is shown at the top of the matrix in Excel.

Microsoft Excel - Finance.xls

File Edit View Insert Format Tools Data Window @RISK Help

Type a question for help

D11

@RISK Correlation Sheet

NewMatrix (3x3)	Sheet1!F25 Number of Competitors	Sheet1!G25 Number of Competitors	Sheet1!H25 Number of Competitors
Sheet1!F25 Number of Competitors	1		
Sheet1!G25 Number of Competitors	0.6	1	
Sheet1!H25 Number of Competitors	0.8	0.55	1

@RISK Correlations Sheet1

Ready

- 2) RiskCorrmat functions are added to each of the input distribution functions that are included in the matrix. The RiskCorrmat function is added as an argument to the distribution function itself, such as:

=RiskNormal(200000, 30000,RiskCorrmat(NewMatrix,2))

where *NewMatrix* is the range name for this matrix and the *2* is the position of the distribution function in the matrix.

After the matrix and RiskCorrmat functions are added to Excel, you can change the coefficient values in your matrix without editing the matrix in the Model window.

Fitting Menu

The Fitting menu commands are used to set up and fit probability distributions to a data set displayed in a fit tab. These commands allow you to run a fit, specify distribution types to be included in a fit and enter binning used in a fit's Chi-Sq tests. The Fitting menu also allows you to filter, sort or otherwise transform the input data that is displayed in the Input data grid on a fit tab.

Run Fit Command

Runs a fit on the input data that is displayed in the Input data grid using the current settings



Run Fit Icon

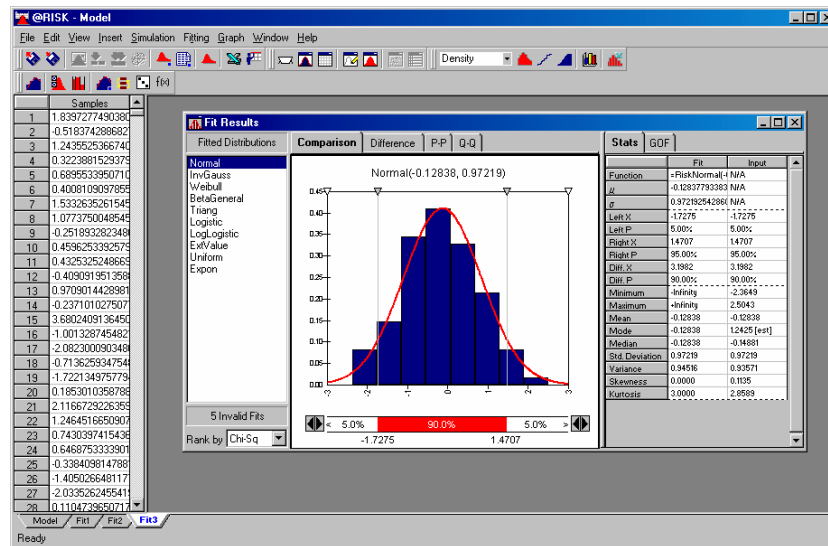
The Run Fit command fits probability distributions to the input data that is displayed in the Input data grid on a fit tab. A fit is run using the current settings as entered using the Fitting menu **Specify Distributions to Fit**, **Define Chi-Sq Binning** and **Input Data Options** commands.

For more information on the techniques used during distribution fitting, see **Chapter 6: Distribution Fitting** in this manual.

Distribution fitting results in a set of theoretical probability distributions that are ranked according to how well they fit your data. These results are displayed in **Fit Results** and **Fit Summary** windows.

Fit Results Window

The Fit Results window displays a list of fitted distributions, graphs that illustrate how the selected distribution fits your data, and statistics on both the fitted distribution and the input data and the results of the goodness-of-fit (GOF) tests on the fit.



Note: No goodness-of-fit test information is generated if the input data type is Density Curve or Cumulative Curve (as set using the **Fitting menu Input Data Options** command). In addition, only **Comparison** and **Difference** graphs are available for these data types.

Fitted Distributions List

The Fitted Distributions list displays all distributions for which valid fit results were generated. These distributions are ranked according to the goodness-of-fit test selected with the **Rank By** entry. Only distribution types selected using the **Fitting menu Specify Distributions to Fit** command are tested when fitting.

Clicking on a distribution listed in the Fitted Distributions list displays the fit results for that distribution, including graphs and statistics on the selected fit.

If a fit did not return valid results for a distribution type, that distribution is not listed in the Fitted Distributions list. The number of invalid fits is shown beneath the list.

Rank By

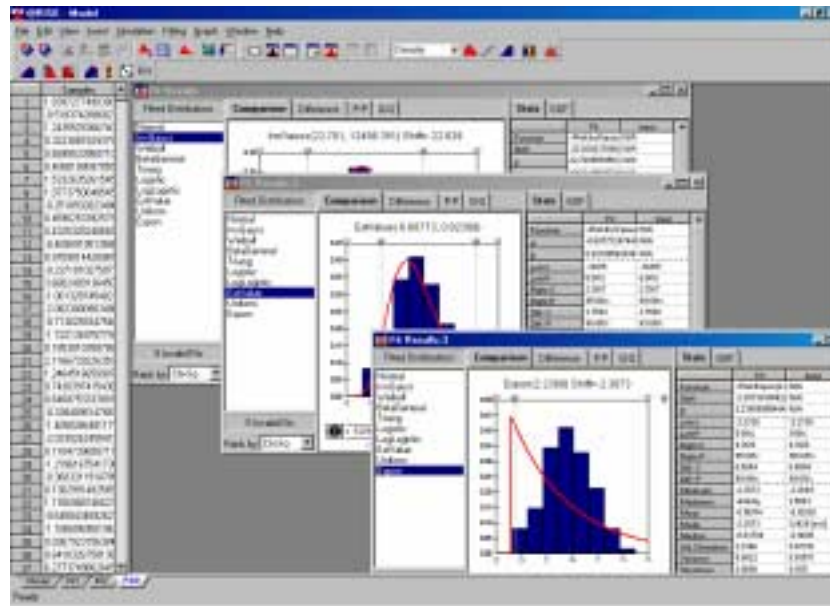
The **Rank By** entry ranks the distributions according to the selected goodness-of-fit test, which measures how well the sample data fit a hypothesized probability density function. Three types of tests are available:

- **Chi Sq** or Chi-Square test. The Chi-Square test is the most common goodness-of-fit test. It can be used with sample input data and any type of distribution function (discrete or continuous). A weakness of the Chi-Square test is that there are no clear guidelines for selecting intervals or bins. In some situations, you can reach different conclusions from the same data depending on how you specified the bins. The bins used in the Chi-Square test can be defined using the **Fitting menu Define Chi-Sq Binning** command.
- **K-S**, or Kolmogorov-Smirnov test. The Kolmogorov-Smirnov test does not depend on the number of bins, which makes it more powerful than the Chi-Square test. This test can be used with sample input data but cannot be used with discrete distribution functions. A weakness of the Kolmogorov-Smirnov test is that it does not detect tail discrepancies very well.
- **A-D**, or Anderson-Darling test. The Anderson-Darling test is very similar to the Kolmogorov-Smirnov test, but it places more emphasis on tail values. It does not depend on the number of intervals.
- **RMS Error**, or root mean squared error. If the input data type is **Density Curve** or **Cumulative Curve** (as set using the **Fitting menu Input Data Options** command), only the RMS Error test is used to fit distributions. For more information on the RMS Error test, see **Chapter 6: Distribution Fitting**.

Displaying Fit Results for Multiple Distributions

To display the fit results for different distributions in the Fitted distribution list at the same time:

- 1) Select the **Insert menu Fit Results Window** command. A new Fit Results window will be displayed on the current fit tab in which results for other fitted distributions can be displayed.

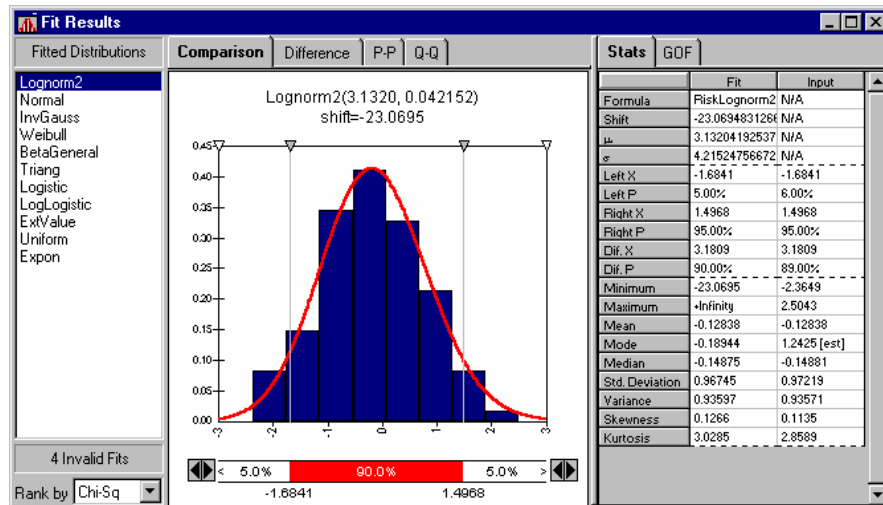


Fit Results – Graphs

When the input data type is Sampled Values, four graphs – **Comparison**, **Difference**, **P-P** and **Q-Q** – are available for any fit selected by clicking in the Fitted Distribution list. If the input data type is **Density Curve** or **Cumulative Curve**, only the **Comparison** and **Difference** graphs are available.

For all graph types **delimiters** may be used to graphically set specific X-P values on the graph. X-axis minimum and maximum values may also be set by dragging the X-axis endpoint delimiters. Delimiters are marked by the inverted triangles above the graph.

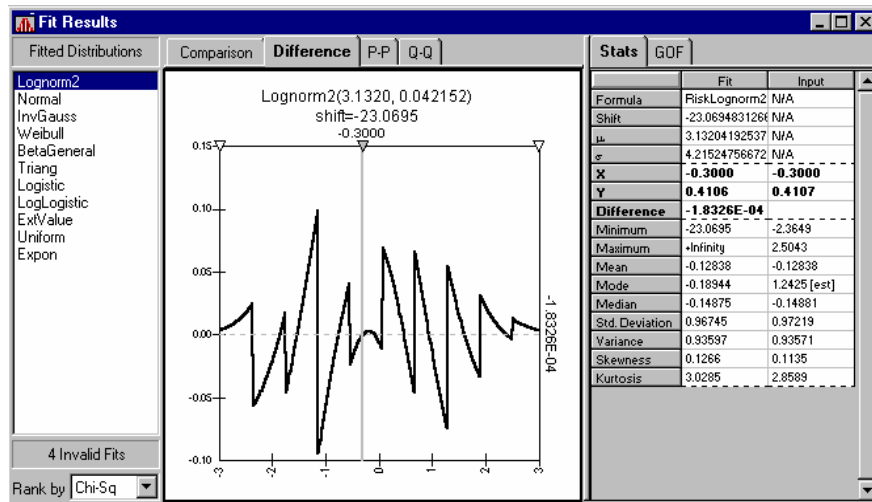
Comparison Graph



A Comparison Graph displays two curves - the input distribution and the distribution created by the best fit analysis.

Two delimiters are available for a Comparison graph. These delimiters set the **Left X** and **Left P** values, along with the **Right X** and **Right P** values. Values returned by the delimiters are displayed in both the probability bar under the graph and in the statistics grid to the right of the graph.

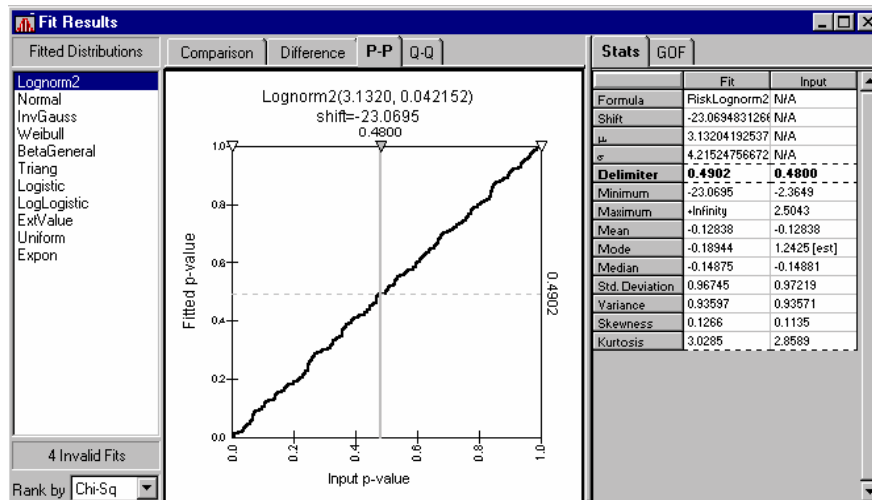
Difference Graph



A Difference graph displays one curve - the difference between the input distribution and the distribution created by the best fit analysis.

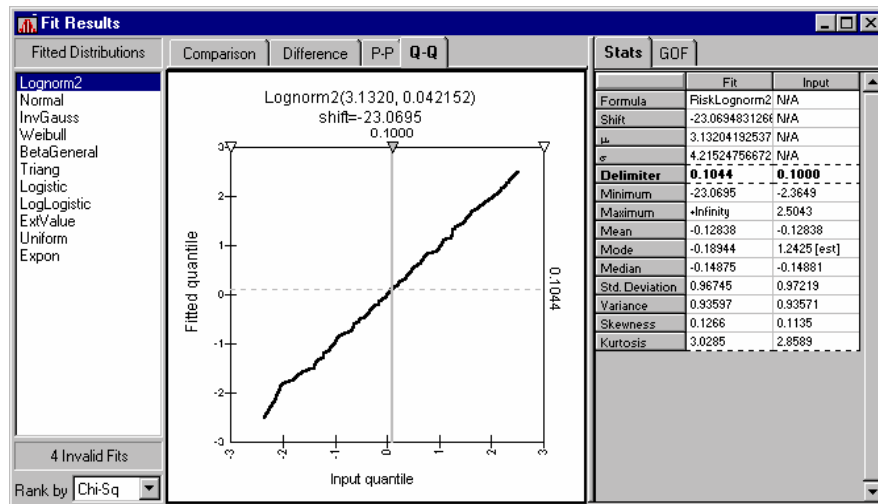
A single delimiter can be used on the Difference graph to return specific X-Y values along with the difference between the input data and the fitted distribution at any X-value on the graph.

P-P Graph



The P-P (or Probability-Probability) graph plots the p-value of the fitted distribution vs. the p-value of the fitted result. If the fit is "good," the plot will be nearly linear. A single delimiter can be used on the P-P graph to return the p-value of the input data and the fitted distribution at any X-value on the graph.

Q-Q Graph

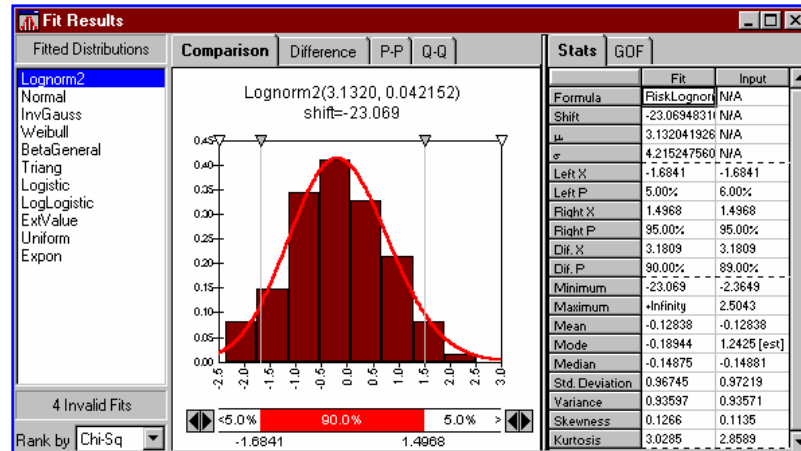


A Q-Q (or Quantile-Quantile graph) plots the plot percentile values of the fitted distribution vs. percentile values of the input data. If the fit is "good," the plot will be nearly linear. A single delimiter can be used on the Q-Q graph to return the percentile value of the input data and the fitted distribution at any X-value on the graph.

Fit Results – Statistics and Goodness of Fit

Statistics on fit results for the currently selected distribution are displayed in the statistics grid in the Results window. Both standard **Stats** and **GOF** (or Goodness of Fit) results are shown on separate tabs. Statistics and GOF results for all fitted distributions can be shown in the Fit Summary window displayed with the **Insert menu Fit Summary Window** command.

Stats



The **Stats** tab in the Fit Results window displays relevant statistics for both the displayed fitted distribution and the distribution of the input data. If a statistic is not valid for either the fitted distribution or the distribution of the input data, *n/a* is shown. Statistics include:

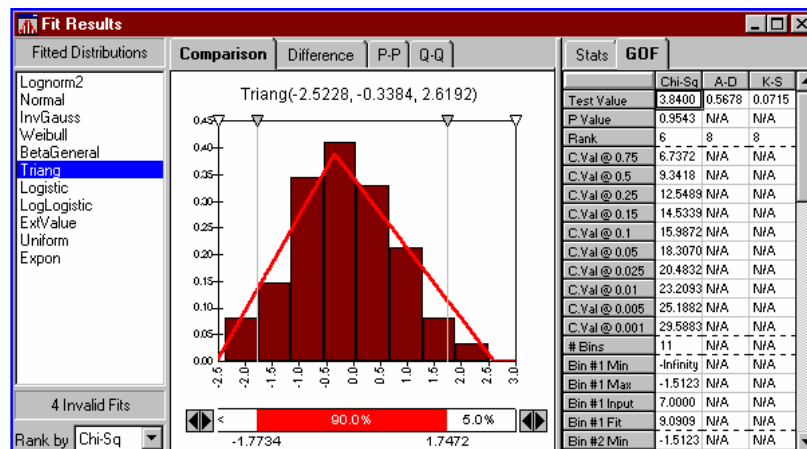
- **Formula**, or distribution and arguments for the fitted distribution. When a fit is used as input for an @RISK model, this formula corresponds with the distribution function that will be placed in your spreadsheet.
- **Parameters**, or an entry for each parameter value included in **Formula**. **Shift** is any X-value shift that is applied if the input data exceeds the range of the fitted distribution. A shifted distribution is expressed in the form *Dist(arg1,arg2...argn) ± Shift*, where a sample drawn from the shifted distribution will have the shift amount added to or subtracted from it. For more information on shift factors, see **Chapter 6: Distribution Fitting**.

- **Delimiter values** (Left and Right X,P entries on Comparison graph, Difference entry on Difference graph, Delimiter entry on P-P and Q-Q graphs). These entries display the current values for delimiters set on a graph.
- **Standard Statistics (Minimum, Maximum, Mean, etc.).** These entries display the statistics calculated for both the displayed fitted distribution and the distribution of the input data.

GOF

The **GOF** (or Goodness of Fit) tab displays the results of goodness-of-fit tests that were calculated during fitting. Test results are displayed for each of the three available tests (Chi-Sq, A-D and K-S) that are performed. Goodness-of-Fit information is only available when the Input Data type is Sampled Values.

The goodness-of-fit statistic tells you how probable it is that a given distribution function produced your data set. The goodness-of-fit statistic can be used for comparing the values to the goodness-of-fit of other distribution functions.



The entries in the GOF report include:

- **Test Value**, or the test statistic for the fitted probability distribution for each of the three tests.
- **P-value**, or observed level of the significance of the fit. For more information on P-values, see **Chapter 6: Distribution Fitting**.
- **Rank**, or the rank of the fitted distribution among all distributions fit for each of the three tests. Depending on the test, the returned rank can change.
- **C Val**, or critical values, at different significance levels for each of the three tests. For more information on critical values and their calculation, see **Chapter 6: Distribution Fitting**.

- **Bin statistics** for each bin for both the input and the fitted distribution (Chi-Sq test only). These entries return the min and max of each bin plus the probability value for the bin for both the input and the fitted distribution. Bin sizes can be set using the **Fitting menu Define Chi-Sq Binning** command.

Fit Results – Fit Summary Window

The Fit Summary window displays a summary of calculated statistics and test results for all distributions fit to the current data set.

Fit Summary Window

Fit Summary						
Rank by	Name					
	Input	BetaGeneral	Expon	ExtValue	InvGauss	Logistic
Formula	N/A	RiskBetaGeneral	RiskExpon(2.23652	RiskExtValue(-0.607	RiskInvGauss(22.69	RiskLogistic(-0.1377
Shift	N/A	N/A	-2.3873	N/A	-22.8281	N/A
Parameter 1	N/A	9.1809	2.2365	-0.6077	22.6998	-0.1377
Parameter 2	N/A	12.3491	N/A	0.9240	1.2497E+04	0.5541
Parameter 3	N/A	-4.0904	N/A	N/A	N/A	N/A
Parameter 4	N/A	5.2007	N/A	N/A	N/A	N/A
Parameter 5	N/A	N/A	N/A	N/A	N/A	N/A
Minimum	-2.3649	-4.0904	-2.3873	-Infinity	-22.8281	-Infinity
Maximum	2.5043	5.2007	+Infinity	+Infinity	+Infinity	+Infinity
Mean	-0.1284	-0.1285	-0.1507	-0.0744	-0.1284	-0.1377
Mode	0.0368 [est]	-0.1985	-2.3873	-0.6077	-0.1901	-0.1377
Median	-0.1488	-0.1500	-0.8370	-0.2691	-0.1284	-0.1377
Std. Deviation	0.9722	0.9681	2.2365	1.1851	0.9675	1.0051
Variance	0.9357	0.9372	5.0021	1.4044	0.9360	1.0102
Skewness	0.1135	0.1200	2.0000	1.1395	0.1279	0.0000
Kurtosis	2.8589	2.7761	9.0000	5.4000	3.0272	4.2000
Target #1 (%)	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%
Target #1 (X)	-1.3101	-1.3723	-2.1516	-1.3784	-1.3348	-1.3553
Target #2 (%)	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%
Target #2 (X)	-0.9808	-0.9697	-1.8882	-1.0474	-0.9281	-0.9059
Target #3 (%)	30.00%	30.00%	30.00%	30.00%	30.00%	30.00%
Target #3 (X)	-0.6436	-0.6671	-1.5896	-0.7792	-0.6301	-0.6072
Target #4 (%)	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%
Target #4 (X)	-0.3629	-0.4020	-1.2448	-0.5269	-0.3722	-0.3624
Target #5 (%)	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%
Target #5 (X)	-0.1488	-0.1500	-0.8370	-0.2691	-0.1284	-0.1377

The following entries are shown in the Fit Summary window:

- **Formula**, or distribution and arguments for the fitted distribution. When a fit is used as input for an @RISK model, this formula corresponds with the distribution function that will be placed in your spreadsheet.
- **Parameters**, or individual entries for each of the distribution parameter values included in **Formula**. **Shift** is any X-value shift that is applied if the input data exceeds the range of the fitted distribution. A shifted distribution is expressed in the form *Dist(arg1,arg2...argn) ± Shift*, where a sample drawn from the shifted distribution will have the shift amount added to or subtracted from it. For more information on shift factors, see **Chapter 6: Distribution Fitting**.
- **Standard Statistics (Minimum, Maximum, Mean, etc.)**. These entries display the statistics calculated for all fitted distributions and the distribution of the input data.

- **Targets** identify the probability of achieving a specific outcome or the value associated with any probability level. Target entries have default values (10% through 95%) that you may change if you wish.

Either values or probabilities may be entered into the target area in the Fit Summary window. If a value is entered, the probability of a value occurring that is less than or equal to the entered value is calculated. If a probability is entered, the value in the distribution whose associated cumulative probability equals the entered probability is calculated. If the @RISK Add-in Options menu **Display Cumulative Descending Percentiles** option is selected, the reported target probability will be in terms of a probability of exceeding the entered target value.

Note: Any target entered in the Fit Summary window is automatically applied to all fitted distributions and the distribution for input data.

For each of the three tests performed (Chi Sq, A-D and K-S) the Fit Summary window displays the information shown on the GOF tab of the Fit Results window. See the **Fit Results – Statistics and Goodness-of-fit** section in this chapter for more information on these statistics.

Rank By

The **Rank By** entry changes the order that fitted distributions are displayed in the Fit Summary window. Select **Name** to list fitted distributions alphabetically, or Chi-Sq, A-D, or K-S to list according to the rankings returned for each test.

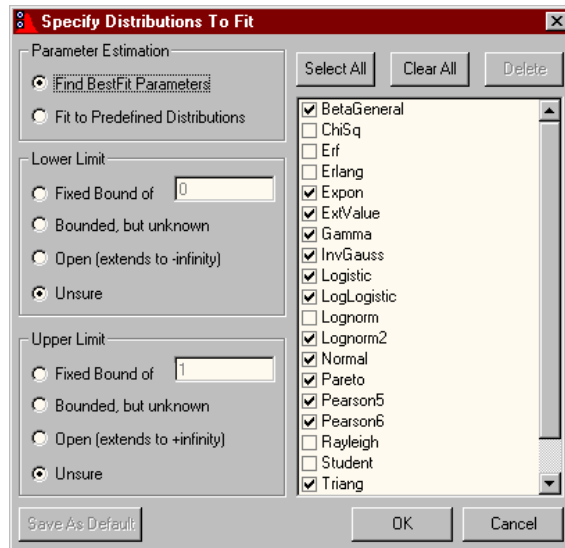
Specify Distributions to Fit Command

Selects probability distributions to fit or specifies a predefined distribution to fit



**Specify
Distributions to
Fit Icon**

The Fitting menu Specify Distributions to Fit command selects the probability distributions to include in a fit. This command can also be used to specify predefined distributions with preset parameter values to fit. Probability distributions to be included in a fit may also be selected by entering information on the lower and upper limits of the allowable distributions.



**Parameter
Estimation**

Parameter Estimation options control whether 1) a group of distribution types will be fitted or 2) a set of predefined distributions will be used. The selection for Parameter Estimation determines the other options that are displayed in the Specify Distributions to Fit dialog. The options available for Parameter Estimation include:

- **Find BestFit Parameters**, or find the parameters for the selected distribution types that best fit your data set.
- **Fit to Predefined Distributions**, or determine how the entered probability distributions (with preset parameters values) fit your data set.

Find BestFit Parameters Options

When **Find BestFit Parameters** is selected, the following options are available in the Specify Distributions to Fit dialog:

- **List of Distribution Types.** Checking or unchecking a specific distribution type will include or remove that type from the fit to be performed. The list of distribution types that are displayed will change depending on the options selected for **Lower Limit** and **Upper Limit**.

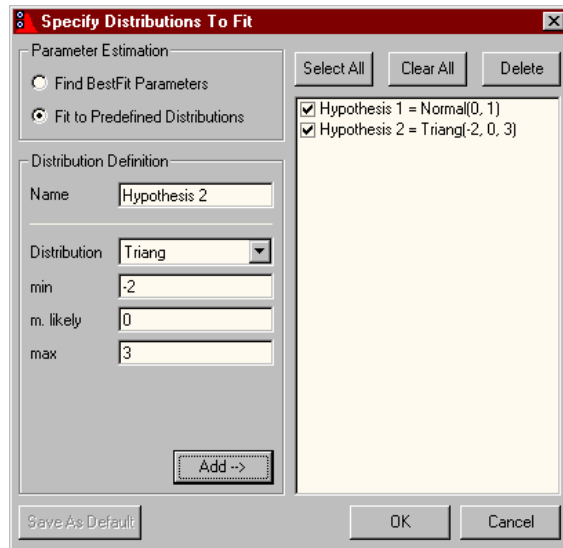
Each distribution type has different characteristics with respect to the range and limits of the data it can describe. Using the **Lower Limit** and **Upper Limit** options you can select the types of distributions to include. Limit options are set based on your knowledge of the range of values which could occur for the item that your input samples describe.

Lower Limit and **Upper Limit** options include:

- **Fixed Bound of.** Specifies a value that will fix the lower and/or upper limit of the fitted distribution to a specific value. Only specific distribution types, such as Triangular, have fixed lower and upper limits. Your entry for Fixed Bound will restrict a fit to certain types of distributions.
- **Bounded, but unknown.** Specifies that the fitted distribution has a finite lower and/or upper limit, but you don't know what the boundary value is.
- **Open (extends to +/- infinity).** Specifies that the data described by the fitted distribution can possibly extend to any possible positive or negative value.
- **Unsure.** Specifies that you are not sure about the possible values that could occur and thus the full range of distributions should be available for fitting.

Fit to Predefined Distributions Options

When **Fit to Predefined Distributions** is selected, a set of predefined distributions are entered and only these predefined distributions will be tested during fitting.



Predefined distributions are specified using the following options:

- **Name.** Specifies the name you wish to give to a predefined distribution.
- **Distribution.** Selects the type of distribution for a predefined distribution from the dropdown list of all available distribution types.
- **Parameter values.** Depending on the type of distribution selected, the possible entries for parameter values will change. Entering the relevant parameter values completes the specification of a predefined distribution.

The **Add button** adds an entered predefined distribution to the list of predefined distributions to be used. Once a set of predefined distributions have been entered, any or all of the entered distributions can be selected for inclusion in a fit. **Select All** selects all predefined distributions in the list to be included in a fit. Alternatively, individual predefined distributions can be selected by clicking on the name of the predefined distribution to be included (holding down the Ctrl-key to select multiple distributions). **Delete** deletes a predefined distribution from the displayed list, and **Clear All** unchecks all entries.

Define Chi-Sq Binning Command

Defines the binning to be used in Chi-Sq goodness-of-fit tests



**Define Chi-Sq
Binning Icon**

The Fitting menu Define Chi-Sq Binning command defines the number of bins, type of bins and custom binning to be used for Chi-Sq goodness-of-fit tests. Bins are the groups that your input data are divided into, similar to the classes used to draw a histogram. Binning can affect the results of Chi-Sq tests and the fit results that are generated. By using the Define Chi-Sq Binning options you can ensure that the Chi-Sq test is using the bins that you deem appropriate. For more information on how the number of bins is used in a Chi-Sq test, see **Chapter 6: Distribution Fitting**.

Note: If you are unsure about the number or type of bins to use for a Chi-Square test, set “Number of Bins” to “Auto” and set “Bin Style” to “Equal Probabilities”.

#	Bin Minima	x	Bin Maxima
1		$<=x<=$	
2		$<x<=$	
3		$<x<=$	
4		$<x<=$	
5		$<x<=$	
6		$<x<=$	
7		$<x<=$	
8		$<x<=$	

The following entries can be used to define Chi-Sq binning:

- **Number of Bins.** Specifies a fixed number of bins or, alternatively, specifies that the number of bins will be automatically calculated for you.

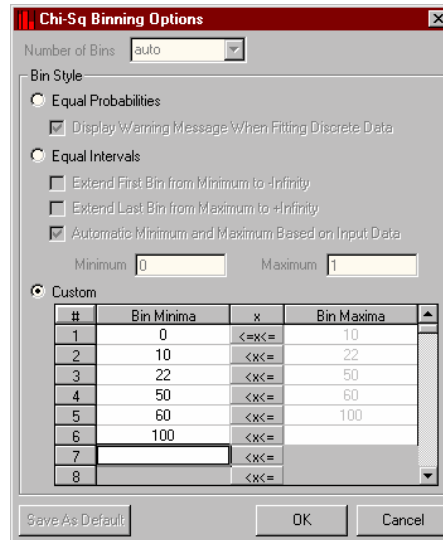
Bin Style Options

Bin Style options specify the style of the binning that will be performed or, alternatively, allow the entry of fully custom bins with user-entered minimum and maximum values. Options for Bin Style include:

- **Equal Probabilities.** Specifies that bins will be made at equal probability intervals across the fitted distribution. This usually results in unequal length bins. For example, if ten bins are used, the first bin would extend from the minimum to the 10th percentile, the second from the 10th percentile to the 20th and so on. In this mode, @RISK will adjust the bin sizes based on the fitted distribution, trying to make each bin contain an equal amount of probability. For continuous distributions this is straight-forward. For discrete distributions, however, @RISK will only be able to make the bins approximately equal.
- **Equal Intervals.** Specifies that bins will be of equal length across the input data set. Several options are available for entering equal interval bins across an input data set. Any or all of these options may be selected:
 - 1) **Extend First Bin from Minimum to -Infinity.** Specifies that the first bin used will stretch from the specified minimum to -Infinity. All other bins will be of equal length. In certain circumstances, this improves fitting for data sets with unknown lower bounds.
 - 2) **Extend Last Bin from Maximum to +Infinity.** Specifies that the last bin used will stretch from the specified maximum to +Infinity. All other bins will be of equal length. In certain circumstances, this improves fitting for data sets with unknown upper bounds.
 - 3) **Automatic Minimum and Maximum Based on Input Data.** Specifies that the minimum and maximum of your data set will be used to calculate the minimum and maximum of equal interval bins. First and last bins, however, may be added based on the settings for **Extend First Bin** and **Extend Last Bin** options described above. If Automatic Minimum and Maximum Based on Input Data is not selected, you can enter a specific **Minimum** and **Maximum** value where your bins will start and end. This allows you to enter a specific range where binning will be performed without regard to the minimum and maximum values in your data set.

Custom Bins

There are times when you wish to have complete control over the bins that are used for Chi-Sq testing. For example, custom bins could be used when there is a natural grouping of collected sample data and you want your Chi-Square bins to reflect that grouping. Entering custom bins allows you to enter a specific minimum-maximum range for each bin that is defined.



The dialog box titled "Chi-Sq Binning Options" has a "Number of Bins" dropdown set to "auto". Under "Bin Style", "Equal Probabilities" is selected with a checked checkbox for "Display Warning Message When Fitting Discrete Data". "Equal Intervals" is also an option, with checkboxes for "Extend First Bin from Minimum to -Infinity", "Extend Last Bin from Maximum to +Infinity", and a checked checkbox for "Automatic Minimum and Maximum Based on Input Data". Below these are input fields for "Minimum" (0) and "Maximum" (1). The "Custom" option is selected, showing a table with 8 rows. The table has columns for "#", "Bin Minima", "x", and "Bin Maxima". The first six rows are filled with values: 0, 10, 22, 50, 60, 100. The last two rows (7 and 8) have empty "Bin Minima" and "Bin Maxima" fields, with the "x" column containing the inequality symbol $<=x<=$. At the bottom are buttons for "Save As Default", "OK", and "Cancel".

#	Bin Minima	x	Bin Maxima
1	0	$<=x<=$	10
2	10	$<=x<=$	22
3	22	$<=x<=$	50
4	50	$<=x<=$	60
5	60	$<=x<=$	100
6	100	$<=x<=$	
7		$<=x<=$	
8		$<=x<=$	

To enter custom bins:

- 1) Click **Custom** in Bin Style. This grays out all automatic binning options.
- 2) Enter a set of minimum or maximum values for your bins. As you enter subsequent values, the range for each bin will be automatically filled in.

Input Data Options Command

Specifies the type of input data to be fitted, its domain and any filtering to be applied to the data



**Input Data
Options Icon**

The Fitting menu Input Data Options command specifies the source and type of input data entered, whether it represents a continuous or discrete distribution and whether it should be filtered in any way.

Data Source

The Data Source options specify the source of the data to be fit. Data can originate in the:

- **Fit Tab Data Grid.** Specifies that the data was typed, loaded or copied into the Data Grid on the left of the Fit Tab by the user.
- **Link to Excel Range.** Specifies a range in Excel that contains the data to be fit. A copy of the data in this range is shown in the Data Grid on the left of the Fit Tab.

Type of Data

The **Type of Data** options specify the type of data that is entered in the Input Data grid on a fit tab. Three different types of data can be entered:

- **Sampled Values.** Specifies that the data is in the form of Sample (or observation) data that are a set of values chosen from a population. The sample data is used to estimate the properties of that population.
- **Density Curve.** Data for a Density curve are in the form of $[X, Y]$ pairs. The Y value specifies the relative height (density) of the density curve at each X value.

- **Cumulative Curve.** Data for a Cumulative Curve are in the form of $[X, p]$ pairs, where each pair has a X value and a cumulative probability p that specifies the height (distribution) of the cumulative probability curve at the X value. A probability p represents the probability of a value occurring that is less than or equal to the corresponding X value.

Depending on the option chosen for Type of Data one column (**Sampled Values**) or two columns (**Density Curve** and **Cumulative Curve**) will be displayed in the Input Data grid.

For more information on how distribution fitting is performed on each of these data types, see **Chapter 6: Distribution Fitting**.

- **Normalize Curve to Unit Area** (Density curve data only).
Selecting this option causes the entered Density curve (in the form of $[X, Y]$ pairs) to be normalized so that the area under the density curve equals one. It is recommended that you select this option to improve fitting of density curve data. Do not use this option if your Y data are taken from a curve that has already been normalized.

Domain

The Domain options specify the domain of the data – **Continuous** or **Discrete** – that is entered in the Input Data grid on a fit tab. These options are only available for the **Sampled Data** type. **Density Curve** and **Cumulative Curve** data are automatically continuous.

Domain options include:

- **Continuous.** Specifies that the distribution described by the input data ranges continuously and any value in the range is possible.
- **Discrete.** Specifies that the distribution described by the input data is discrete and only integral values – and none in between – are possible. If Discrete is selected, the **Data in counted format** option is available. This option specifies that the input data will be in the form of $X, Count$ pairs, where *Count* specifies the number of points that fall at value X .

The selected Domain option will affect the distributions that can be fitted to the data set as selected using the **Fitting menu Specify Distributions to Fit command** (i.e., only discrete distributions will be fitted if Discrete Domain is selected).

Filtering Options

Filtering allows you to exclude unwanted values outside an entered range from your input data set. Filtering lets you specify outliers in your data that will be ignored during fitting. For example, you may wish to only analyze X values greater than zero. Or, you may wish to filter out tail values by only looking at data within a few standard deviations of the mean. Filtering options include:

- **No Filtering.** Specifies that the data will be fitted as entered.
- **Filter Data Outside Range.** Specifies a minimum X-value, a maximum X-value or both to define a range of valid data to be included in a fit. Values outside the entered range will be ignored. If just a minimum or just a maximum is entered for the range, the data will be filtered only below the entered minimum or above the entered maximum.
- **Filter Data that Falls X Standard Deviations beyond the Mean.** Specifies that data outside the entered number of standard deviations from the mean will be filtered from the data set prior to fitting.

Automatically Run Fit When Input Data Changes

A fit can be automatically updated when the input data in the Data Grid or the referenced data range in Excel changes. If **Automatically Run Fit When Input Data Changes** is selected, a new fit will be run when @RISK detects that the data has changed.

Input distribution functions in Excel can also be automatically updated when a fit changes due to a change in data. Input distribution functions are linked to a fit on a fit tab via the **RiskFit** function. When a fit referenced by a RiskFit function changes, @RISK will automatically update the probability distribution function to reflect the new fit results either 1) automatically or 2) when a new simulation starts or the Outputs and Inputs list is generated.

Updating an @RISK function in Excel could include:

- **Changing the distribution function to a new type**, such as when the RiskFit function includes the argument "*Best Chi-Sq*". In this case the new distribution function entered in Excel will be the best fit returned by the Chi-Sq test performed during the new fit.
- **Changing the distributions' arguments**, such as when the RiskFit function includes the argument "*Normal*". In this case the new distribution function entered in Excel will be Normal with the best fitting arguments returned by the new fit.

The Fitting menu command **Update Linked @RISK Functions** command controls how the @RISK functions in your model update when a fit they are derived from changes.

Sort Data Command

Sorts the data set displayed in the input data grid

The Fitting menu Sort Data command sorts the current data set in ascending order. For cumulative curve and density curve data types, data is sorted by X value.



Sort Data Icon

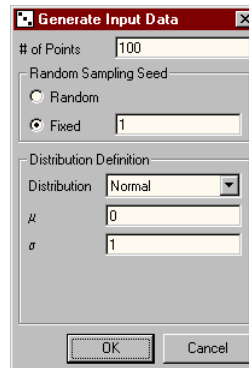
Generate Data Command

Generates a new data set in the input data grid using random samples from an entered distribution

The Fitting menu Generate Data command generates a new data set in the input data grid on the current fit tab by drawing samples from an entered probability distribution. By using the Generate Data command you can quickly generate sets of random data from specific distributions for testing distribution fitting.



Generate Data Icon



The following options are available for generating input data:

- **# of Points.** Specifies the number of points to be generated.
- **Random Sampling Seed.** Selecting **Random** causes a new set of random samples from an entered distribution to be generated each time the Generate Data command is selected. Using a **Fixed** seed causes the same sequence of samples to be generated each time the Generate Data command is selected for the same distribution.
- **Distribution Definition.** Specifies the distribution from which samples will be drawn to generate the input data set. Options include:

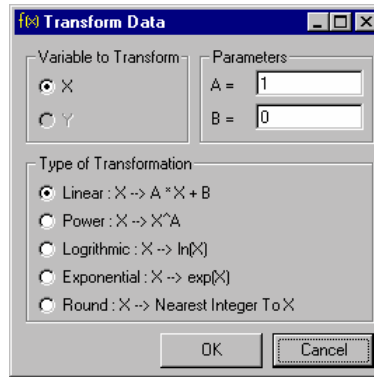
- 1) **Distribution.** Specifies the type of distribution for a predefined distribution from the dropdown list of all available distribution types.
- 2) **Parameter values.** Depending on the type of distribution selected, the possible entries for parameter values will change.

Clicking OK in the Generate Input Data dialog causes a new data set with the specified number of points to be generated, overwriting the current data set.

Transform Data Command

Generates a new data set in the input data grid by modifying the current data set using a selected transformation

The Fitting menu Transform Data command modifies the current data set according to a transformation you select. Available types of transformations include **Linear**, **Power**, **Logrithmic**, **Exponential** and **Round**.



Options in the Transform Data dialog include:

- **Variable to Transform.** Selects the variable of the data set to transform. When the input data type is **Sampled Values**, only X values can be transformed; however, when the input data type is **Density Curve** and **Cumulative Curve**, X or Y values can be transformed.
- **Parameters.** Specifies the parameter value to be used in the transformation for **Linear** and **Power** transformations. Enter the appropriate value as shown in the equations listed **under Type of Transformation**.
- **Type of Transformation.** Selects the type of transformation to be performed on the current input data.

Note: Once a transformation is performed, the data set in the input grid is permanently changed.

Update Linked @RISK Functions Command

Selects the method used for updating @RISK distribution functions which are based on fitted data

The **Fitting menu Update Linked @RISK Functions command** allows you to select how @RISK distributions in Excel are updated when they are linked to a fit. This allows you to insure that the distributions in your model stay current when fitted data changes.

An @RISK distribution function in Excel can be linked to a data set and the fit of that data set. The data used in a fit can be either in Excel or on a fit tab in the @RISK – Model window. A link is made by the **RiskFit** function. When the fitted data changes in either one of these locations, the following actions take place:

- 1) @RISK re-runs the fit using the current settings on the fit tab where the fit was originally run
- 2) The distribution function that includes the RiskFit function that references the fit is changed to reflect the new fit results. The changed function replaces the original one in Excel. If, for example, the distribution function's RiskFit argument specified "**Best Chi-sq**" for *selected fit result*, the new best-fitting distribution based on the Chi-Sq test would replace the original one. This new function would also include the same RiskFit function as the original one.

When @RISK will perform the above actions depends on the setting selected for the **Update Linked @RISK Functions command**.

Available options are:

- **Always**, or immediately update distribution functions when the data and fit have changed.
- **Only on Simulation Start or List Update**, or update when a simulation starts or the list of Outputs and Inputs is generated.
- **Never**, or disable links and don't update when fits change.

The Update method used affects all linked distributions. It may be helpful to select **Only on Simulation Start or List Update** when re-fitting **takes too much time and frequent changes are made to fitted datasets**.

Graph Menu

Format Graph Command

Changes the type or appearance of the current graph

The Graph menu Format Graph command changes the appearance of the selected graph. Use this command to change the type, scaling, style and titles of your graphs and turn delimiters on and off.

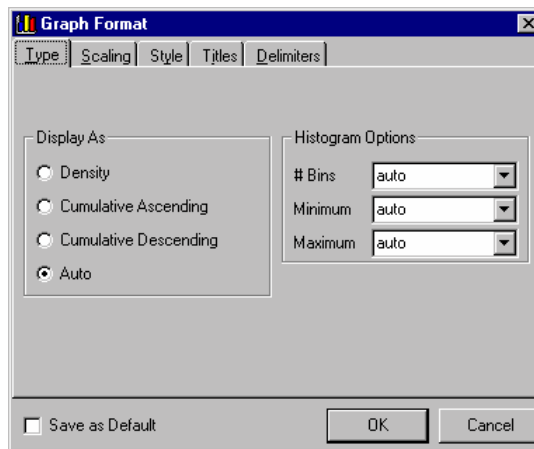
Save as Default

Clicking Save as Default sets the current format settings as the default. All new graphs generated will use these defaults.

Type Tab – Graph Format Command

Changes the type and format of a displayed graph

The Type tab on the Graph Settings dialog box allows you to change the type of a displayed graph.



- **Display As.** Displays a graph in density, cumulative ascending or cumulative descending format. **Auto** specifies that the type of graph displayed will be based on the type of input data entered. In this case, graphs will be displayed in density format except when the curves being graphed would naturally be displayed in cumulative format.

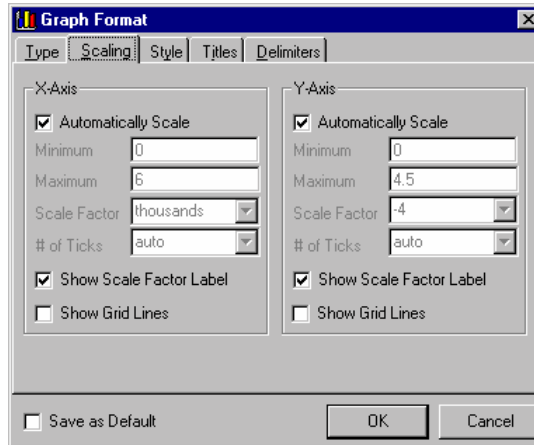
- **#Bins.** Sets the number of histogram intervals calculated across the range of a graph. The value entered must be in the range 1 to 200. The setting **Auto** calculates the best number of bins to use for your data using an internal heuristic.
- **Minimum.** Sets the minimum value where histogram bins start. **Auto** specifies that @RISK will start the histogram bins based on the minimum of the data graphed.
- **Maximum.** Sets the maximum value where histogram bins end. **Auto** specifies that @RISK will end the histogram bins based on the maximum of the data graphed.

Scaling Tab – Graph Format Command

Changes the scaling, units and axis tick marks on the active graph

The available Scaling options allow you to rescale the current graph, set the number of X and Y axis ticks, set the scale factor with which values are displayed and display gridlines on the graph. You can also select to have @RISK automatically scale the X and Y axis of a graph.

Note: X-axis scaling can also be changed by dragging the delimiters at the X-axis endpoints using the mouse directly on the graph.



- **Automatically Scale.** Specifies that @RISK will automatically calculate X or Y axis minimum and maximum values based on the range and probabilities of the data displayed in the graph.

Note: Clicking the AutoScale button in the top right corner of a graph selects the Automatically Scale option and rescales the graph.

- **X-Axis Maximum.** Enters the X-axis maximum value for the current graph. This specifies the maximum value shown on the horizontal X-axis of the displayed graph. Values are entered in terms of actual values with all digits. Using the current scale factor, @RISK converts those values to the appropriate units (in thousands, in millions, etc.) for display. X-axis scaling may be adjusted to include all of a distribution or just a portion of it. This allows you to view only a piece of a distribution when more detail is desired.
- **X-Axis Minimum.** Enters the X-axis minimum value for the current graph. Information given for the X-maximum option also applies to X-minimum.

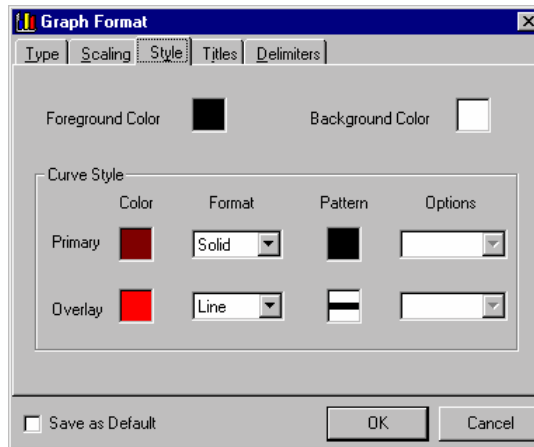
- **Y-Axis Maximum.** Enters the Y-axis maximum value for the current graph. This specifies the maximum probability value displayed on the Y-axis.
- **Y-Axis Minimum.** Enters the Y-axis minimum value for the current graph.
- **# of Ticks.** Defines the number of ticks drawn on the X-axis or Y-axis between the origin and the extreme values.
- **Scale Factor.** Sets the factor used in displaying units on the X- and Y-axis in @RISK graphs. Factors are entered as the listed unit names (thousands, millions, etc.) or as powers of 10.
- **Show Scale Factor Label.** Specifies that the scale factor will be labeled on the X and Y axes.
- **Show Grid Lines.** Specifies if Y or X-axis grid lines are to be displayed.

When @RISK initially scales a graph it calculates a default scale factor based on the magnitude of the values displayed in the graph. Entering a new scale factor causes the units displayed (i.e., in thousands, in millions, etc.) to change.

Style Tab – Graph Format Command

Changes the color, format and pattern of elements in the displayed graph

The Style tab in the Graph Format dialog box changes the colors, format and patterns on a displayed graph.



Foreground and Background Color

The Foreground and Background Color options set the color of the foreground and background elements in the displayed graph. Colors can be selected by clicking on the box to the right of the **Color** entry.

Curve Style

The **Curve Style** options change the color, format, pattern and other options of the current graph and its overlays. The **Format**, **Pattern** and **Options** available change with the type of the graph displayed.

The **Format** settings include:

- **Points Format.** Graphs unconnected points at each point on the density or cumulative curve.
- **Line Format.** Graphs cumulative line graph or density curve line graph.
- **Bars Format.** Graphs standard histogram bars.
- **Solid Format.** Graphs all curves with the area under the curve filled.

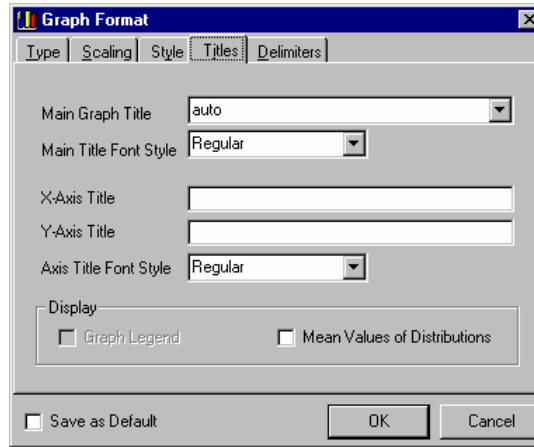
Pattern options include a variety of available line, point and fill patterns.

When an overlay is present, the **Overlay** entry displays the color, format, pattern and options for the overlay graph.

Titles Tab – Format Command

Allows the entry of custom titles for a graph

The Titles tab allows the entry of a custom title for the top of any graph, along with custom X- and Y-axis titles. Font style may also be set for titles.



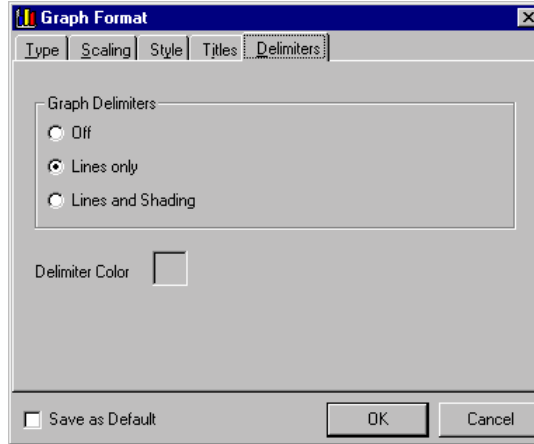
- **Main Graph and Axis Titles.** Changes a selected title. Titles may also be formatted using any of the font styles listed in the dropdown font style entries.
- **Display.** Adds or removes the @RISK-generated labels on graphs - **Legend** (graphs with overlays only) and **Expected Value**.

Text and graphics may also be placed on graphs using the drawing and text editing capabilities of your spreadsheet. Using the @RISK Edit menu Copy command, the active graph can be transferred to the Clipboard where it can be pasted into your spreadsheet as a Windows Metafile. Once pasted, the graph can be resized and text and graphics may be attached to it.

Delimiters Tab – Graph Format Command

Selects the display mode for delimiters on a histogram graph or cumulative graph

Delimiters can be displayed on any graphs to allow 1) the setting of target probabilities directly on the graph and 2) X-axis rescaling. Delimiters are marked by inverted triangles at the top of a graph.



Delimiters can be turned on and off as desired and shading between delimiters can be displayed or removed. The color of delimiters and their associated shading can be specified by clicking on the box to the right of the **Delimiter Color** entry.

Using Delimiters

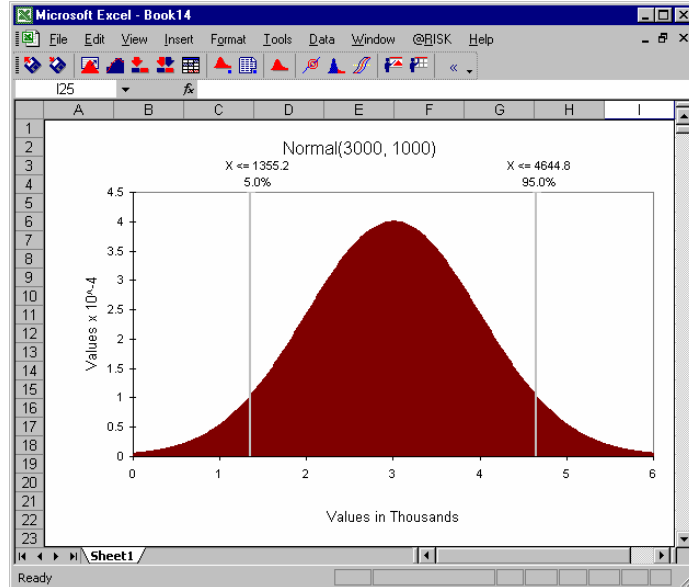
To move delimiters:

- 1) Click and drag any of the four delimiters marked by an upside down triangle at the top of the graph to the desired location. When a comparison graph is displayed, moving probability delimiters also updates the **Left X, Left P, Right X, Right P, X(diff) and P(diff)** in the displayed Statistics tab. The **diff** statistics show the value and probabilities falling between the left and right probability delimiters. On a difference graph, delimiters update the **X,Y** and **difference** entries in displayed Statistics tab. For P-P and Q-Q graphs, moving the single delimiter updates the **Delimiter** entry in the displayed Statistics tab.

Graph in Excel Command

Draws the selected graph in Microsoft Excel in the spreadsheet's native format

The Graph menu Graph in Excel command places the selected graph data points in an Excel worksheet. Then, a native format graph is created on the worksheet from the data points.



Once the graph is created, it can be customized and rescaled using Excel's editing features. Please consult your spreadsheet's documentation for more information on editing the graphs.

For histograms, bar heights can be changed directly in Excel by changing the relevant series data.

Delimiter Defaults Command

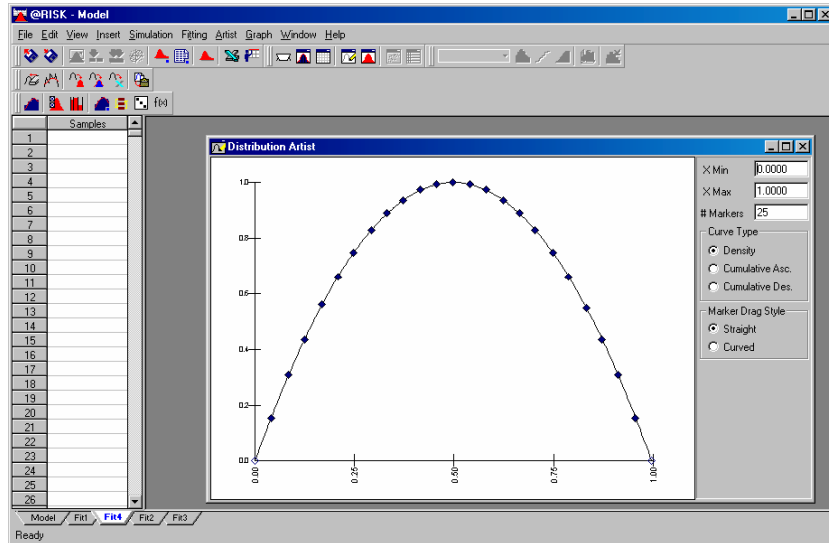
Specifies the position of the left and right delimiters for all distribution graphs

The Graph menu Delimiter Defaults command specifies the starting delimiter positions for new distribution graphs. These settings affect all new distribution graphs for all models.

Artist Menu

The Artist window is used to draw freeform curves that can be used to create probability distributions. The commands on the Artist menu control both how drawing is performed in the Artist window and how a probability distribution is created from a drawn curve. The Artist menu is only available when an Artist window is the active window.

Artist Window



Drawing in the Artist Window

After an Artist window has been inserted using the **Insert menu Artist Window** command, a curve may be drawn simply by dragging the mouse through the window. The following entries in the Artist window control the scaling and type of graph that is drawn:

- **X Min and X Max.** Specifies the X-axis scaling for the drawn graph.
- **# Markers.** Sets the number of markers that will be drawn as you drag across the min-max range of the graph. Markers allow you to drag the points on the curve to change its shape.
- **Curve Type.** Specifies the type of curve that will be created, where **Density** is a probability density curve, **Cumulative Asc.** is an ascending cumulative curve and **Cumulative Des.** is a descending cumulative curve.
- **Marker Drag Style.** Specifies whether markers will be connected with straight lines or curves when they are moved.

If you are drawing an ascending cumulative distribution (as specified in the Curve Typeoption), you will only be able to draw a curve with ascending Y values, and vice-versa for a descending cumulative curve.

When you have completed a curve, the end-points on your curve will be automatically plotted.

After drawing a curve, you may want to "drag" one of the markers to a new location. Simply click the left mouse button on the marker and, while holding down the button, drag the point to a new location. When you lift the button, the curve is redrawn automatically to include the new data point.

You can only move data points along the Y-axis, and you cannot drag points outside the axes. You cannot modify the positions of the end points.

Clear Curve Command

Erases the curve in the active Artist window

The Artist menu Clear Curve command erases the curve in the active Artist window.

Smooth Curve Command

Smooths the curve in the active Artist window

The Artist menu Smooth Curve command smooths the curve in the active Artist window. Repeated selection of the Smooth Curve command makes a progressively smoother (and flatter) curve.

Copy Command

Copies data from the active Artist window to the clipboard

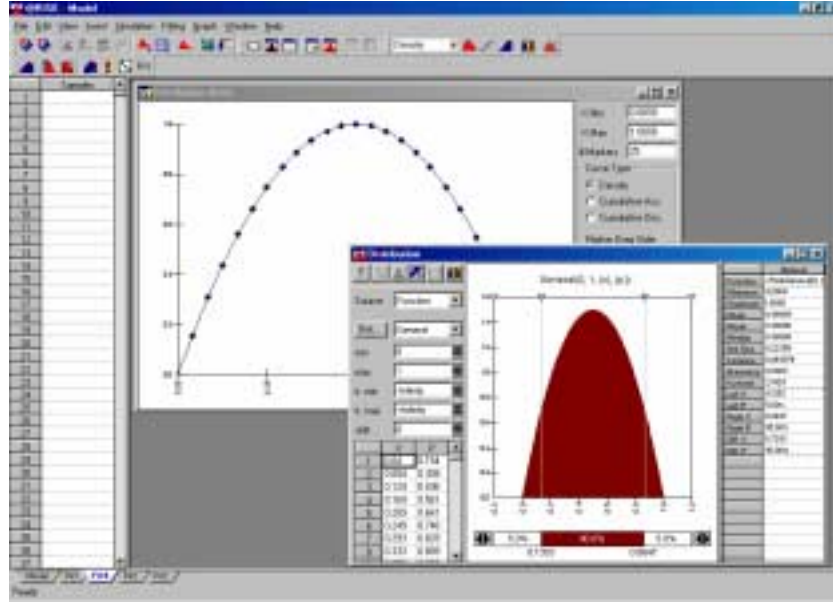
The Artist menu Copy command copies the selected data or the graph from the Artist window to the Clipboard. **All Points** copies all X and Y data points which define the drawn curve, including those calculated on lines connecting markers. **Marked Points** copies X and Y data points for markers only. **Graph** places a copy of the drawn graph in the clipboard.

Create Distribution Command

Creates a General distribution from the drawn curve

The Artist menu Create Distribution command creates a General distribution from a drawn curve. A General distribution is a user-defined @RISK distribution that takes a *minimum* value, a *maximum* value and a set of *X,P* data points which define the distribution.

General Distribution from a Curve in an Artist Window



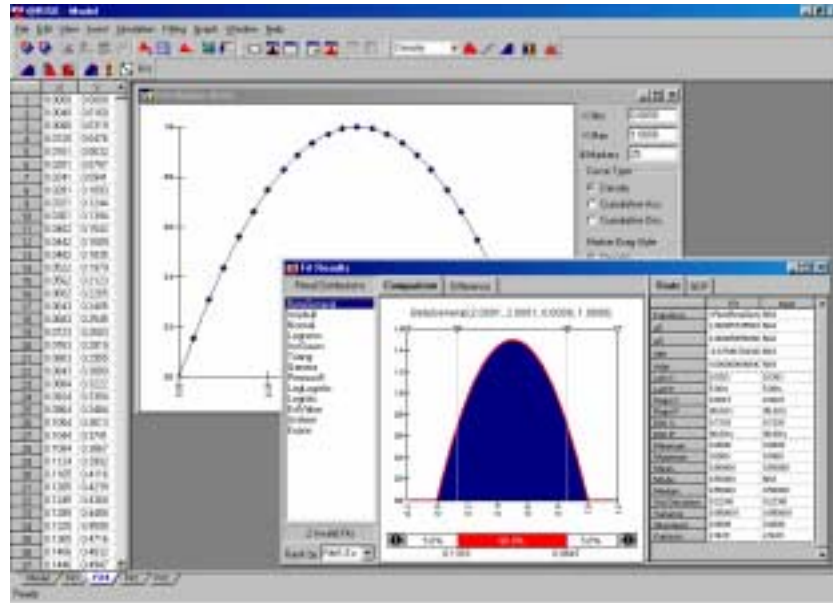
When the Artist menu Create Distribution command is selected, the General distribution created from a curve in an Artist window is displayed in a Distribution window. By using the Copy command this distribution can be placed in an @RISK **Define Distribution** window where it can be used to define an @RISK input.

Fit Curve Command

Fits a drawn curve to a probability distribution

The Artist menu Fit Curve command fits a probability distribution to a drawn curve. When a drawn curve is fitted, the X and Y values associated with the curve are placed in the Input Data grid and fit. The results of the fit are displayed in a standard Fit Result window where each of the fitted distributions can be reviewed.

*Fitted
Distribution
from a Curve in
an Artist
Window*

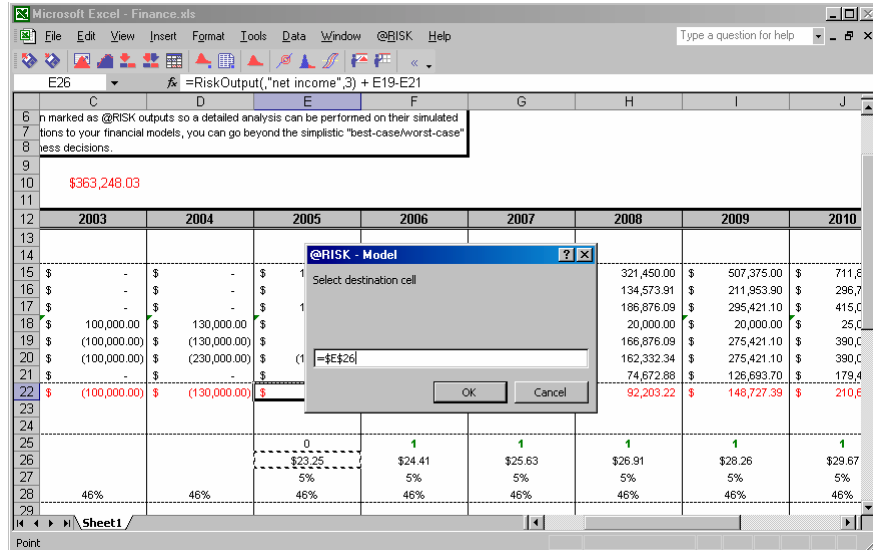


Fitting a drawn curve uses the same fitting techniques used for either Density Curve input data (if the drawn curve type is **Density**) or Cumulative Curve input data (if the drawn curve type is **Cuml.Ascending** or **Cuml.Descending**). For more information on input data types, see the **Fitting Menu: Input Data Options Command**. For more information on fitting Density Curve input data and Cumulative Curve input data, see **Chapter 6: Distribution Fitting**.

Write Function to Excel Command

Writes the General probability distribution defined by the curve in the Artist window to a cell in Excel

The Artist menu Write Function to Excel command creates a RiskGeneral distribution function from the drawn curve and allows you to select a cell in Excel to place the function in. The RiskGeneral distribution function created is identical to the function created when the Artist menu Create Distribution command is selected.



Window Menu

Show Excel Window Command

Shows Excel and the @RISK add-in

The Window menu Show Excel Window command shows the Excel window and the @RISK add-in. To show the @RISK Model window again, click the Show Model Window icon in the @RISK toolbar.

Show Results Window Command

Shows the @RISK Results window

The Window menu Show Results Window command shows the @RISK Results window. To show the @RISK Model window again, click the Show Model Window icon in the @RISK toolbar.

Cascade Command, Tile Command

Arranges open windows and graphs in the @RISK Model window

The Window menu Cascade and Tile commands cascade or tile the open windows neatly within the @RISK Model window.

List of Available Windows

Lists all open windows in the @RISK Model window

The bottom items in the Window menu list all open windows in the current tab in the @RISK Model window (the active window is noted with a check mark). To activate a window, select its name from the list.

Help Menu

How Do I?

Opens the How Do I guide for @RISK

The Help menu How Do I? command opens the How Do I guide for @RISK. This contains quick instructions in how to perform many common @RISK tasks.

@RISK Help, Distributions Help

Opens on-line help files for @RISK

The Help menu @RISK Help command opens the main help file for @RISK. All of @RISK's features and commands are described in this file.

The Help menu Distributions Help command opens the distribution help file for @RISK. Information on all of @RISK's distribution functions, including formulas, statistics and graphs, is included in this file.

Online Manual

Opens on-line manual for @RISK

The Help menu Online Manual command opens this manual on-line in PDF format. You must have Adobe Acrobat reader installed to view the online manual.

Authorization Command

Displays authorization information for @RISK and allows the authorization of trial versions

The Help menu Authorization command displays the Authorization dialog box, listing the version and authorization information for your copy of @RISK. Using this dialog box you can also convert a trial version of @RISK into an authorized copy.

About Command

Displays version and copyright information about @RISK

The Help menu About command displays the About dialog box, listing the version and copyright information for your copy of @RISK

Reference: @RISK Results Window Commands

File Menu

New Command

Clears all active @RISK simulation data and results

The New command clears all active @RISK simulation data from the Results and Model windows and resets @RISK settings to their default values.

Open Command

Opens a saved @RISK simulation



Open Icon

The File Open command opens a previously saved simulation data file (.RSK file) including simulation settings, all input data and graphs (with supporting fitted datasets) and simulation results including any generated graphs. For more information on the File Open command, see **File Open** in **Reference: @RISK Add-In Menu Commands**.

Save Command, Save As Command

Saves the current @RISK simulation data



Save Icon

The File menu Save and Save As commands save the current @RISK data in a .RSK file. For more information on the File Save and Save As commands, see **File Save** in the **@RISK Add-In Menu Commands** section.

Print Command

Prints the current graph or report

The Print command prints the active Results window graph.

Exit Command

Unloads the @RISK add-in from Excel

The File menu Exit command unloads the @RISK add-in in Excel and shuts down the supporting @RISK-Model and @RISK-Results windows. If you shut down @RISK during an Excel session, you can restart it at a later time by clicking the @RISK icon on the DecisionTools toolbar.

Edit Menu

Copy Command

Copies @RISK reports and graphs to the Windows Clipboard

The Edit menu Copy command is used to transfer @RISK reports and graphs to the Clipboard so they can be pasted into your spreadsheet or word processor. The report or graph to be copied is determined by the current active window in @RISK. The active window is the one with its title bar highlighted.

@RISK graphs are copied to the clipboard as Windows metafiles. When placed in your spreadsheet they may be resized and annotated.

Paste Command

Pastes the current contents of the Clipboard into an @RISK statistics report

The Edit menu Paste command is used to transfer the Clipboard contents into the editable area of an @RISK statistics report. The editable area of the report is the section of the report where Scenarios, Filters and Targets are entered.

Fill Down Command

Copies an entered target across a set of simulation results

The Edit menu Fill Down command is used to copy an entered target in the Summary Statistics window. To use the Fill Down command:

- 1) Enter the desired value in a cell in the $x1=$, $x2=$, $p1=$ or $p2=$ column in the window.
- 2) Highlight the range you wish to copy the value down with the mouse, with the cell with the value to be copied as the first cell in the range.
- 3) Select the Edit menu Fill Down command. The value will be "filled" into each cell in the range and the corresponding target values or probabilities calculated.

Fill Right Command

Copies an entered target, scenario or filter across a set of simulation outputs

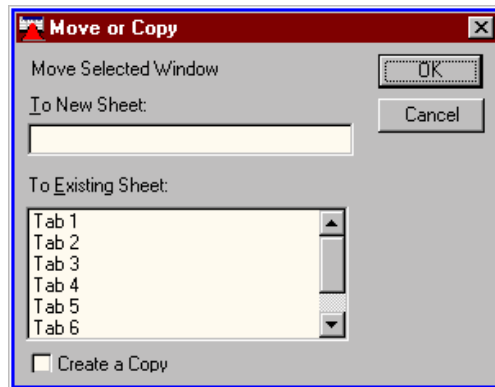
The Edit menu Fill Right command is used to copy an entered target, scenario or filter across a row in the Detailed Statistics window. To use the Fill Right command:

- 1) Enter the desired value in a cell in the report.
- 2) Highlight the range you wish to copy the value across with the mouse, with the cell with the value to be copied as the first cell in the range.
- 3) Select the Edit menu Fill Right command. The value will be "filled" into each cell in the range.

Move or Copy Window Command

Copies or moves a displayed window to a different tab

The Edit menu Move or Copy Window Command moves or copies windows between tabs.



Using the Move or Copy command you can rearrange your windows so logical groups of windows are placed on the same tab.

Delete Tab Command

Deletes the current tab

The Delete Tab command (also selected by right-clicking on a Tab at the bottom of the Results window and selecting Delete) deletes the current tab. All open windows on the current tab are also deleted.

Rename Tab Command

Renames the current tab

The Rename Tab command (also selected by right-clicking on a Tab at the bottom of the Results window and selecting Rename) renames the current tab.

View Menu

Turns display of screen elements on and off

The View menu options allow you to optionally display or not display the @RISK Results window toolbars, Explorer and status bar, and customize the displayed toolbars.

Insert Menu

The Insert menu commands insert new windows on the current tab or inserts a new tab. Multiple copies of any window can be inserted on a tab.

Tab Command

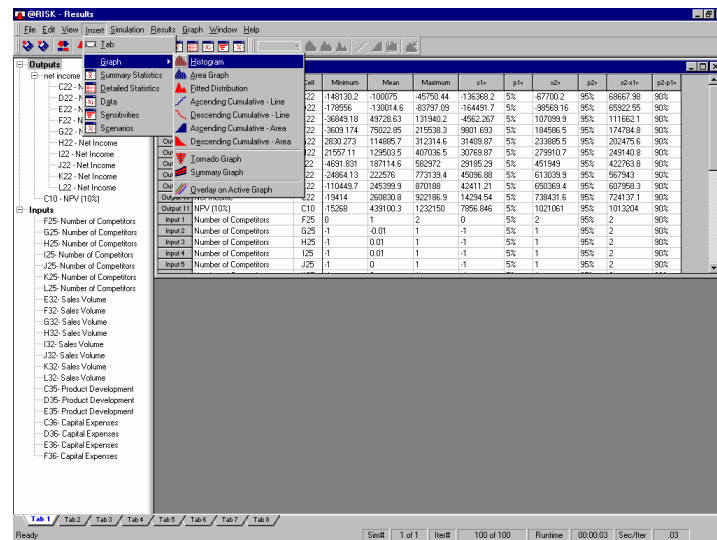
Inserts a new tab before the current tab

The Insert Tab command inserts a tab before the current tab. These commands can also be selected by right-clicking on a Tab at the bottom of the @RISK Results window.

Graph Command

Inserts new graph window(s) on the current tab

The Insert menu Graph command allows you to insert one or more graph windows on the current tab. The type of graph that will be inserted is determined by the menu item selected from the Graph command.



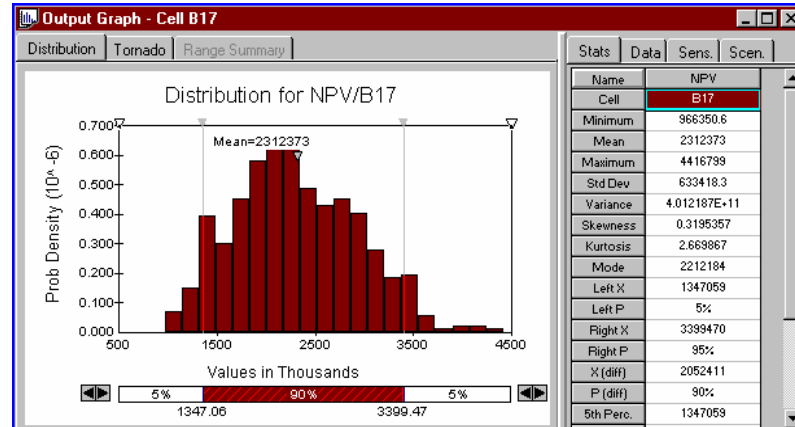
The Insert menu Graph command displays a graph for each entry currently selected in the Results window Explorer list. By holding down the <Ctrl> or <Shift> key to select multiple variables in the Explorer list, multiple results can be graphed.

A variety of graphs of simulation results can be generated in the Results Window:

Histogram and Cumulative Graphs



Histogram and Cumulative Graph Icons



Graphs of simulation results are generated when 1) an output or input is “right-clicked” in the Explorer list and a graph command is selected or 2) the Insert Graph command is selected. Graphs may be generated for:

- **Output cells**, where the graph displays the distribution of values calculated during the simulation for the output cell selected.
- **Input distribution functions**, where the graph displays the distribution of values sampled during the simulation from the distribution function selected.

Graphs are displayed using the default graph type and patterns. The available graph types and patterns are described in the **Graph menu Format Graph command** later in this section.

Multiple graphs can be created for any simulation result. To create additional graphs, simply highlight the appropriate entry in the Explorer list and right-click.

The statistics, data, sensitivities and scenarios for the graphed output or input are displayed in the tabbed report to the right of the graph. For graphs of simulation outputs, clicking on the Graph tab changes the displayed graph to either a Tornado graph of the same output or a Summary graph of the output range of which includes the output.

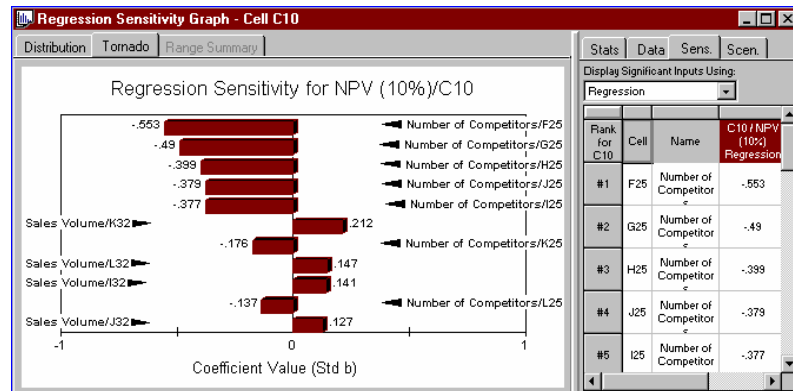
Note: The amount of the window devoted to the graph and reports can be changed by moving the separator bar between the two parts of the window. By default, enlarging the window by dragging makes the Graph larger, while maintaining a constant report size. If you hold down the <Ctrl> key while stretching the window the report will be made larger while maintaining a graph size.



**Tornado Graph
Icon**

Tornado Graphs

Graphs of sensitivity analysis results are created when an output is “right-clicked” in the Explorer list and Tornado Graph is selected from the pop-up menu (or the Insert menu Graph Tornado Graph command is selected).



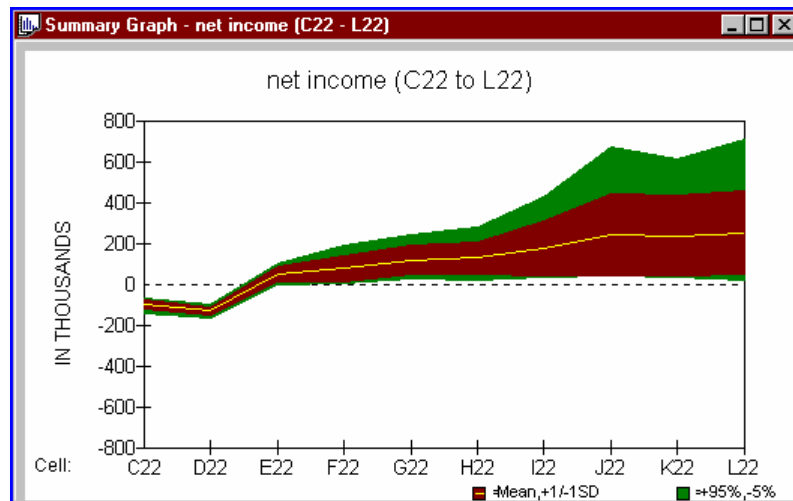
A "tornado graph" can be displayed for either regression or correlation coefficients. Changing the **Display Significant Inputs Using Entry**: switches a Tornado graph between Regression and Correlation sensitivity results. The length of the bar shown for each input distribution function is based on the coefficient value calculated for the input. For more information on the coefficient values that are calculated in a Sensitivity analysis, see the **Insert Menu Sensitivities Command** later in this chapter.



Summary Graph Icon

Summary Graphs

Summary graphs are created when the Insert menu Graph Summary Graph command is selected (or an output or output range is “right-clicked” in the Explorer list and Summary Graph is selected from the pop-up menu). Summary Graphs are only available for multiple cell output ranges. This type of output range is created when a set of cells is highlighted in your worksheet and the Add Output icon is clicked. If multiple simulations have been run, multiple summary graphs may be displayed in the same graph window to allow the comparison of results by simulation.



A Summary graph summarizes changes in probability distributions across an output range. When an output range contains multiple cells, a distribution of possible outcomes is calculated for each cell in the range. The Summary graph takes five parameters from each distribution — the mean, two upper and two lower band values and graphs the changes in the five parameters across the output range. The upper band values default to +1 standard deviation and the 95th percentile of each distribution, while the two lower band values default to -1 standard deviation and the 5th percentile of each distribution. These may be changed by using the **Type** options in the **Graph Menu Graph Format** dialog box.

The Summary graph is especially useful in displaying changes in risk over time. An output range may be an entire worksheet row — such as Profit by Year. The Summary graph would then show the trends in the distributions for profit year to year. The wider the band around the mean the larger the variability in possible results.

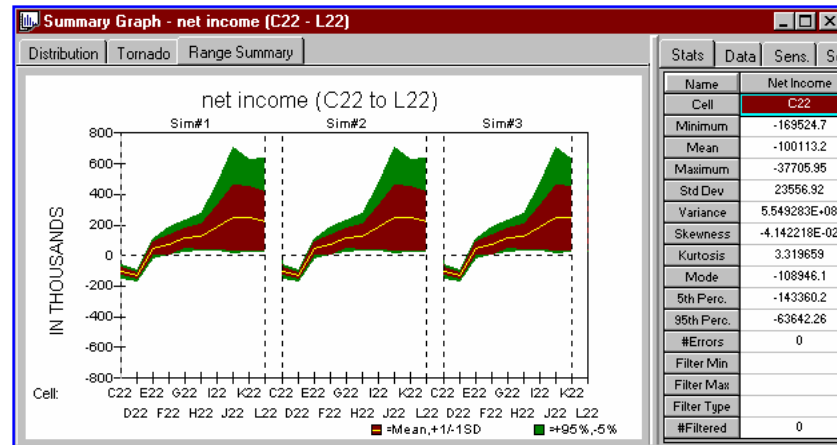
Summary graphs may be rescaled on both the X- and Y-axis. See the section on the **Graph Format Dialog Box Scaling Options** in this chapter for more information on rescaling.

When generating a Summary graph, @RISK calculates the mean and the four band values (such as 5th and 95th percentile) for each cell in the output range graphed. These points are graphed with hi-lo lines. Patterns in-between the points for each cell are then added. The mean and two band values for these added points are calculated by interpolation.

Summary Graphs from Multiple Simulations

When multiple simulations are run and multiple cell output range(s) have been selected, a summary graph is available for each multiple cell output range in each simulation. Often it is desirable to compare the summary graphs created for the same output range in different simulations. This comparison shows how the trend in expected value and risk changes for the output range by simulation.

Summary Graph from One Output Range in Three Simulations

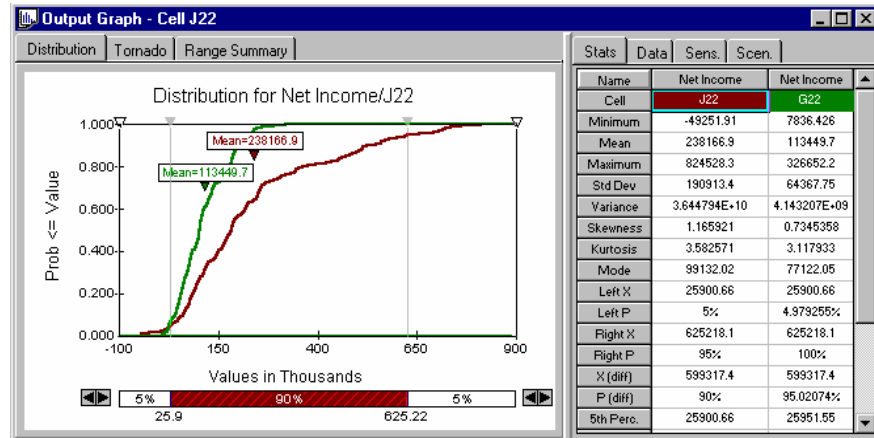


To create a summary graph that compares the results for a single output range in multiple simulations:

- 1) Run multiple simulations by setting the **# of Simulations** in the Simulation Settings dialog box to a value greater than one. Use the **RiskSimtable** function to change worksheet values by simulation.
- 2) Right-click on output range you wish to graph in the Explorer and select Summary Graph.
- 3) Select the entry *Sim#1 to Sim#n* in the Graph Output Range Summary dialog box (where n is the number of simulations run) and click OK.

Overlay Graphs

An overlay graph is created when the **Insert menu Graph Overlay on Active Graph command** is selected (or an output is “right-clicked” in the Explorer list and **Overlay on Active Graph** is selected from the pop-up menu). This command is only available when the active window is a histogram or cumulative graph of a simulation output.



Multiple outputs may be overlaid at the same time by holding the <Ctrl> key or <Shift> key while selecting outputs in the Explorer list, prior to selecting **Overlay on Active Graph** from the pop-up menu.

Overlays may be removed using the Variables to Graph tab in the Graph Format dialog box. For more information on doing this, and for more information on overlay graphs themselves, see the **Variables To Graph Tab – Graph Format Command** later in this chapter.



Insert Summary Statistics Window Icon Summary Statistics Window

Summary Statistics Command

Inserts a new Summary Statistics window on the current tab

The Insert menu Summary Statistics command (also invoked by clicking the Summary Statistics icon) displays a summary of the simulation results for both output cells and inputs.

	Name	Cell	Minimum	Mean	Maximum	x1	p1	x2	p2	s2-x1	p2-p1	Errors
Output 1	Net Income	C22	-160314.7	-99866.42	-51794.68	-139320.5	5%	-64281.88	95%	75038.57	90%	0
Output 2	Net Income	D22	-183188.1	-129981.7	-79945.46	-165017.3	5%	-100800.9	95%	64216.41	90%	0
Output 3	Net Income	E22	-55523.49	49420.46	155828.4	-7961.544	5%	105394.6	95%	113356.2	90%	0
Output 4	Net Income	F22	2103.454	74903.26	230172	11786.14	5%	181079.2	95%	169293	90%	0
Output 5	Net Income	G22	20916.62	116910.4	302958.6	31255.63	5%	255559.1	95%	224303.5	90%	0
Output 6	Net Income	H22	10477.93	123469.9	325231.5	28109.16	5%	270328.1	95%	242219	90%	0
Output 7	Net Income	I22	1492.957	184970.6	516124.1	31558.14	5%	432124.9	95%	400566.8	90%	0
Output 8	Net Income	J22	-13924.48	229361.6	860855.4	35926.75	5%	605874.6	95%	569947.9	90%	0
Output 9	Net Income	K22	-45489.72	234600.1	776179.9	35728.77	5%	635193.9	95%	599465.2	90%	0
Output 10	Net Income	L22	-14212.31	253562.3	817568.1	25258.12	5%	730909.4	95%	705651.3	90%	0
Output 11	NPV (10%)	C10	-21750.53	431538	1104930	-11149.14	5%	863000.8	95%	874149.9	90%	0
Input 1	Number of Competitors	F25	0	1	2	0	5%	2	95%	2	90%	0
Input 2	Number of Competitors	G25	-1	0.01	1	-1	5%	1	95%	2	90%	0
Input 3	Number of Competitors	H25	-1	0.01	1	-1	5%	1	95%	2	90%	0
Input 4	Number of Competitors	I25	-1	-0.01	1	-1	5%	1	95%	2	90%	0
Input 5	Number of Competitors	J25	-1	0	1	-1	5%	1	95%	2	90%	0

The Summary Statistics window displays the minimum, mean and maximum values calculated for all output cells and input distributions that were sampled. In addition, two target values and probabilities ($x1$ and $p1$, along with $x2$ and $p2$) along with the number of errors calculated are displayed.

Targets in the Summary Statistics Window

The values and probabilities in the $x1$, $p1$, $x2$ and $p2$ columns may be edited and the new corresponding value or probability will be calculated. The **Edit menu Fill Down** command can be used to quickly copy a target across a group of outputs and/or inputs. Using this you can quickly calculate a statistic such as the 99th percentile for all results.

	Name	Cell	Minimum	Mean	Maximum	x1	p1	x2	p2	s2-x1	p2-p1	Errors
Output 1	Net Income	C22	-160314.7	-99866.42	-51794.68	-139320.5	5%	-52870.82	99%	86449.64	94%	0
Output 2	Net Income	D22	-183188.1	-129981.7	-79945.46	-165017.3	5%	-82215.36	99%	82801.95	94%	0
Output 3	Net Income	E22	-55523.49	49420.46	155828.4	-7961.544	5%	122411.5	99%	130373	94%	0
Output 4	Net Income	F22	2103.454	74903.26	230172	11786.14	5%	209717.8	99%	197931.6	94%	0
Output 5	Net Income	G22	20916.62	116910.4	302958.6	31255.63	5%	268508.6	99%	237253	94%	0
Output 6	Net Income	H22	10477.93	123469.9	325231.5	28109.16	5%	318573.9	99%	290464.7	94%	0
Output 7	Net Income	I22	1492.957	184970.6	516124.1	31558.14	5%	507827.1	99%	476268.9	94%	0
Output 8	Net Income	J22	-13924.48	229361.6	860855.4	35926.75	5%	689945.1	99%	654018.3	94%	0
Output 9	Net Income	K22	-45489.72	234600.1	776179.9	35728.77	5%	710153.6	99%	674424.8	94%	0
Output 10	Net Income	L22	-14212.31	253562.3	817568.1	25258.12	5%	803322.9	99%	778064.8	94%	0
Output 11	NPV (10%)	C10	-21750.53	431538	1104930	-11149.14	5%	1051225	99%	1062374	94%	0
Input 1	Number of Competitors	F25	0	1	2	0	5%	2	99%	2	94%	0
Input 2	Number of Competitors	G25	-1	0.01	1	-1	5%	1	99%	2	94%	0
Input 3	Number of Competitors	H25	-1	0.01	1	-1	5%	1	99%	2	94%	0
Input 4	Number of Competitors	I25	-1	-0.01	1	-1	5%	1	99%	2	94%	0
Input 5	Number of Competitors	J25	-1	0	1	-1	5%	1	99%	2	94%	0



**Insert Detailed
Statistics
Window Icon
Detailed
Statistics
Window**

Detailed Statistics Command

Inserts a new Detailed Statistics window on the current tab

The Insert menu Detailed Statistics command (also invoked by clicking the Detailed Statistics icon) displays detailed statistics on the simulation results for output cells and inputs.

Detailed Statistics							
Name	Net Income	Net Income	Net Income	Net Income	Net Income	Net Income	Net Income
Description	Output	Output	Output	Output	Output	Output	Output
Cell	C22	D22	E22	F22	G22	H22	I22
Minimum =	-152716.4	-185287	-36068.71	7174.115	294.8279	24407.72	-5033.746
Maximum =	44529.87	-78251.04	155374.8	186559	286040.8	353394.7	618545.9
Mean =	-100027.7	-130007.5	49580.95	73846.66	117358.5	124670	190139.3
Std Deviation =	22109.62	20291.77	36401	55620.07	70118.54	75081.24	145764.3
Variance =	4.888353E+08	4.117558E+08	1.325033E+09	3.093592E+09	4.91661E+09	5.637193E+09	2.124722E+10
Skewness =	5.458337E-02	2.502181E-02	6.890728E-02	0.6250554	0.5790781	0.7838445	1.057024
Kurtosis =	2.949351	2.776228	2.898723	1.936289	2.33229	2.768825	3.367823
Errors Calculated =	0	0	0	0	0	0	0
Mode =	-102073.3	-115612	47444.52	7393.342	193193.1	74092.58	105765.1
5% Perc =	-138337	-164438.7	-17130.02	8794.652	27113.17	32609.38	28245.49
10% Perc =	-129352.8	-155712	2695.515	15586.17	42742.5	45910.29	35831
15% Perc =	-121161.7	-152495.7	11057.13	18515.93	48489.05	51574.61	54104.75
20% Perc =	-117316.3	-146485.9	18059.1	22810.02	54290.52	56068.01	64752.97
25% Perc =	-113166.2	-143798	25245.49	26510.61	61021.5	64257.78	84620.13
30% Perc =	-111184.3	-140908.1	31073.06	28974.27	64744.61	71262.49	97692.43
35% Perc =	-109011.5	-138293.1	34733.32	35367.14	71182.92	76881.77	105264.1
40% Perc =	-105976.9	-136655	37711.96	39368.29	81037.94	86548.69	120298.5
45% Perc =	-102690.4	-131816.6	46990.66	48601.65	88895.36	90136.88	133472.5
50% Perc =	-100897.5	-130200.8	49547.25	55429	99483.88	97999.84	153827.9
55% Perc =	-98551.99	-127232.6	55928.91	63704.8	104829	106201.7	167391.8
60% Perc =	-96689.97	-124808.4	57937.78	70645.69	125679.3	121530.2	175094.2
65% Perc =	-93111.19	-122885.3	64330.36	79719.71	139840.2	144303.1	196842.2
70% Perc =	-88310.62	-119875.8	67559.02	95034.81	156895.6	161813.3	218385.3
75% Perc =	-86870.39	-115891.9	71075.58	126448.3	170714.5	179902.3	252764.8
80% Perc =	-84165.02	-112679.4	80309.7	139318.6	187347.5	189101.5	311738.5
85% Perc =	-77304.41	-108211.1	93221.34	152323.4	196222.4	214078.6	364181.1
90% Perc =	-68817.42	-103860.5	97850.78	162492.5	219384.5	226174.4	407027.2
95% Perc =	-64495.27	-97947.35	104265	170536.4	237792.2	255067.6	499287

The Detailed Statistics window displays relevant statistics that were calculated for all output cells and input distributions that were sampled. In addition, percentile values (in increments of 5 perc%) are shown, along with filter information and up to 10 target values and probabilities.

**Entering Target
Values in the
Detailed
Statistics
Window**

Targets in @RISK may be calculated for any simulation result — either a probability distribution for an output cell or a distribution for a sampled input distribution. These targets identify the probability of achieving a specific outcome or the value associated with any probability level. Either values or probabilities may be entered into the target entry area at the bottom of the Detailed Statistics window.

Detailed Statistics							
Name	Net Income	Net Income	Net Income	Net Income	Net Income	Net Income	Net Income
Description	Output	Output	Output	Output	Output	Output	Output
Cell	C22	D22	E22	F22	G22	H22	I22
60% Perc =	-96689.97	-124908.4	57937.78	70645.69	125679.3	121530.2	175094.2
65% Perc =	-93111.19	-122885.3	64330.36	79719.71	139940.2	144903.1	196642.2
70% Perc =	-89310.62	-119875.8	67559.02	95034.81	156899.6	161813.3	218385.3
75% Perc =	-86870.39	-115891.9	71075.58	126448.3	170714.5	179902.3	252764.8
80% Perc =	-84165.02	-112679.4	80309.7	139318.6	187347.5	189101.5	311738.5
85% Perc =	-77304.41	-108211.1	83221.34	152323.4	196222.4	214078.6	364181.1
90% Perc =	-68817.42	-103860.5	97850.78	162492.5	219384.5	226174.4	407027.2
95% Perc =	-64495.27	-97947.35	104265	170536.4	237732.2	255067.6	499287
Filter Minimum =							
Filter Maximum =							
Type 11 or 21 =							
# Values Filtered =	0	0	0	0	0	0	0
Scenario #1 =	>75%	>75%	>75%	>75%	>75%	>75%	>75%
Scenario #2 =	<25%	<25%	<25%	<25%	<25%	<25%	<25%
Scenario #3 =	>90%	>90%	>90%	>90%	>90%	>90%	>90%
Target #1 (Value)=	-49817.796875	-86552.7109375	125519.6484375	184477.3125	283452.46875	308329.25	596578
Target #1 (Perc%)=	99%	99%	99%	99%	99%	99%	99%
Target #2 (Value)=							
Target #2 (Perc%)=							
Target #3 (Value)=							
Target #3 (Perc%)=							
Target #4 (Value)=							

The target entry area is viewed by scrolling the Detailed Statistics window to the target rows where values and probabilities can be entered. If a value is entered, @RISK calculates the probability of a value occurring that is less than or equal to the entered value. If the @RISK Add-in Options menu **Display Cumulative Descending Percentiles** option is selected, the reported target probability will be in terms of a probability of exceeding the entered target value.

If a probability is entered, @RISK calculates the value in the distribution whose associated cumulative probability equals the entered probability.

Copying Targets Across Simulation Results

Once a target value or probability has been entered, it may be quickly copied across a range of simulation results by simply dragging the value across the range of cells you wish to enter it in. An example of this is shown above, with the 99% target entered for each of the output cells in the Detailed Statistics window. To copy targets:

- 1) Enter the desired target value or probability in a single cell in the Detailed Statistics window target rows.
- 2) Highlight a range of cells across the row adjacent to the entered value by dragging the mouse across the range.
- 3) Select the Edit menu Fill Right command and the same target will be calculated for each of the simulation results in the highlighted range.

Data Command



**Insert Data
Window Icon**

Inserts a new Data window on the current tab

The Insert menu Data command (also invoked by clicking the Insert Data Window icon) displays data values calculated during a simulation for output cells and inputs. A simulation generates a new set of data for each iteration of the simulation. During each iteration a value is sampled for each input distribution and a value is calculated for each output cell. Selecting the Insert Data command displays the simulation data in a worksheet where it can be further analyzed or exported (using the @RISK Edit menu Copy command) to another application for additional analysis.

Data Window

Name	Net Income	Net Income	Net Income	Net Income	Net Income	Net Income
Description	Output	Output	Output	Output	Output	Output
Iteration# / Cell	C22	D22	E22	F22	G22	H22
1	-119937.87500	-97947.35156	5349.29736	21550.77344	49720.04297	96563.17969
2	-138337	-111842.48438	56139.40625	78534.84375	61716.72266	82774.32031
3	-122045.98438	-100322.79688	58238.21484	73155.40625	65982.25781	56068.01172
4	-113003.25781	-78251.03906	29641.77344	48467.86328	286040.78125	180371.40625
5	-51891.57031	-114016.35156	25245.49219	170640.95313	163177.62500	48364.32813
6	-95658.85156	-131816.60938	18448.32227	26510.60547	43598.68750	34898.37109
7	-123706.07031	-103947.42188	28466.48047	15586.16504	99483.88281	226138.42188
8	-123441.46875	-141482.28125	66728.62500	39368.28516	156899.60938	45910.28906
9	-147208.15625	-165078.60938	59543.90234	31356.39453	52076.88672	206577
10	-137417.81250	-162450.78125	-17130.01953	32402.95117	68271.65625	180882.65625
11	-68817.42188	-94096.45313	540.73322	166544.34375	74221.78125	209271.28125
12	-97088.96094	-138123.92188	111451.28906	154901.06250	59950.71094	283691.53125
13	-112025.25000	-87783.32813	47395.75000	134564.87500	219384.53125	178984.89938
14	-83755.71094	-166825.04688	-6446.67432	27329.09180	86657.21875	67233.70313
15	-64798.53516	-122277.21875	37711.96484	131960.03125	146502.56250	255067.60938
16	-117316.25000	-106077.03125	239.58969	16326.58887	144243.45313	82638.62500
17	-49817.79688	-108049.98438	14043.25098	70645.58750	107041.82813	96491.72656
18	-111197.24219	-136855.01563	92448.88938	74079.35156	103288.27344	88973.96094
19	-93201.11719	-102577.64063	57663.23438	28974.26953	88895.35938	34953.69141
20	-85320.47556	-101736.75781	125919.64844	50576.22266	139840.23438	233635.82813
21	-108272.32031	-115565.21094	75966.19531	121976.37500	196222.35938	54419.06641
22	-96689.96875	-154980.50000	64431.79688	27748.29688	54706.68959	161813.25000
23	-102690.43750	-144048.90625	57937.77734	186598.98438	153384.45313	101345.41406
24	-76104.84375	-146238.70313	82360.01563	69090.21094	81037.93750	32528.93359
25	-105564.04688	-107687.13281	5264.51416	48601.65234	27113.16797	106201.68750
26	-89303.68750	-152495.67188	36020.28516	152323.43750	139270.20313	247592.40625
27	-65348.78125	-136303.90625	73155.97656	139318.62500	63468.12891	222357.96875

Data is displayed by iteration for each output cell and sampled input distribution. By moving across a row of the Simulation Data window you can see the exact combination of input samples which led to the shown output values in any given iteration.



Insert Sensitivities Icon

Sensitivities Command

Inserts a new Sensitivity Analysis window on the current tab

The Insert menu Sensitivities command (also invoked by clicking the Insert Sensitivities Window icon) displays sensitivity analysis results for output cells. These results show the sensitivity of each output variable to its input variables.

Sensitivity Analysis										
Rank Inputs for Output:				Display Significant Inputs Using:						
C22 / Net Income				Regression						
Rank for C22	Cell	Name	Distribution	C22 / Net Income Regression	D22 / Net Income Regression	E22 / Net Income Regression	F22 / Net Income Regression	G22 / Net Income Regression	H22 / Net Income Regression	
#1	C36	Capital Expenses	RiskNormal(50000,20000)	-.901	-0	-0	0	0	0	
#2	C35	Product Development	RiskNormal(50000,10000)	-.444	-0	0	0	0	0	
#3	K25	Number of Competitors	RiskDiscrete((-1,0,1),(1,1,1))	0	0	-0	0	0	0	
#4	J25	Number of Competitors	RiskDiscrete((-1,0,1),(1,1,1))	-0	0	-0	.06	0	0	
#5	F32	Sales Volume	RiskNormal(5000,1000)	0	0	-0	.327	-.083	0	
#6	G25	Number of Competitors	RiskDiscrete((-1,0,1),(1,1,1))	0	0	0	0	-.639	-.355	
#7	E32	Sales Volume	RiskNormal(3000,1000)	0	0	.968	0	-.117	0	
#8	F25	Number of Competitors	RiskDiscrete((0,1,2),(1,1,1))	-0	-0	0	-.904	-.424	-.331	
#9	F36	Capital Expenses	RiskNormal(10000,1000)	0	0	-0	0	0	0	
#10	L25	Number of Competitors	RiskDiscrete((-1,0,1),(1,1,1))	0	-0	0	0	0	0	

The Sensitivity analysis performed on the output variables and their associated inputs uses either a multivariate stepwise regression analysis or a rank order correlation analysis. The input distributions in your model are ranked by their impact on the output whose name is selected in the drop-down listbox titled **Rank Inputs for Output**. The type of data displayed in the table – **Regression**, **Correlation** or **Both** – is selected in the drop-down listbox titled **Display Significant Inputs Using**.

Two methods are used for calculating sensitivity analysis results, as discussed here:

Multivariate Stepwise Regression

What is Linear Regression?

Regression is simply another term for fitting data to a theoretical equation. In the case of linear regression, the input data is fit to a line. You may have heard of the "Least-Squares" method, which is a type of linear regression.

Multiple regression tries to fit multiple input data sets to a planar equation that could produce the output data set. The sensitivity values returned by @RISK are normalized variations of the regression coefficients.

**What is
Multivariate
Stepwise
Regression?**

Stepwise regression is a technique for calculating regression values with multiple input values. Other techniques exist for calculating multiple regressions, but the stepwise regression technique is preferable for large numbers of inputs since it removes all variables that provide an insignificant contribution from the model.

The coefficients listed in the @RISK sensitivity report are normalized regression coefficients associated with each input. A regression value of 0 indicates that there is no significant relationship between the input and the output, while a regression value of 1 or -1 indicates a 1 or -1 standard deviation change in the output for a 1 standard deviation change in the input.

The **R-squared** value listed at the bottom of the column is simply a measurement of the percentage of variation that is explained by the linear relationship. If this number is less than ~ 60% then the linear regression does not sufficiently explain the relationship between the inputs and outputs and another method of analysis should be used.

Even if your sensitivity analysis produces a relationship with a large value of **R-squared**, examine the results to verify that they are reasonable. Do any of the coefficients have an unexpected magnitude or sign?

Rank Order Correlation

**What is
Correlation?**

Correlation is a quantitative measurement of the strength of a relationship between two variables. The most common type of correlation is linear correlation, which measures the linear relationship between two variables.

The rank order correlation value returned by @RISK can vary between -1 and 1. A value of 0 indicates there is no correlation between variables; they are independent. A value of 1 indicates a complete positive correlation between the two variables; when the input value samples "high," the output value will sample "high." A value of -1 indicates a complete inverse correlation between the two variables; when the input value samples "high," the output value will sample "low." Other correlation values indicate a partial correlation; the output is affected by changes in the selected input, but may be affected by other variables as well.

What is Rank Order Correlation?

Rank order correlation calculates the relationship between two data sets by comparing the rank of each value in a data set. To calculate rank, the data is ordered from lowest to highest and assigned numbers (the ranks) that correspond to their position in the order.

This method is preferable to linear correlation when we do not necessarily know the probability distribution functions from which the data were drawn. For example, if data set A was normally distributed and data set B was lognormally distributed, rank order correlation would produce a better representation of the relationship between the two data sets.

Comparison of Methods

So, which measurement of sensitivity should you use? If the **R-squared** value reported by the Stepwise Regression is low, you can conclude that the relationship between the input and output variables is not linear. In this case, you should use the Rank-Order Correlation analysis to determine the sensitivity in your model.

If the **R-squared** value reported by the Stepwise Regression is high, it is easy to conclude that the relationship is linear. But, as mentioned above, you should always verify that the regression variables are reasonable. For example, @RISK might report a significant positive relationship between two variables in the regression analysis and a significant negative correlation in the rank-order analysis. This effect is called multicollinearity.

Multicollinearity occurs when independent variables in a model are correlated to each other as well as to the output. Unfortunately, reducing the impact of multicollinearity is a complicated problem to deal with, but you may want to consider removing the variable that causes the multicollinearity from your sensitivity analysis.



Insert Scenarios Window Icon

Scenarios Command

Inserts a new Scenario Analysis window on the current tab

The Insert menu Scenarios command (also invoked by clicking the Insert Scenarios Window icon) displays scenario analysis results for output cells. Up to three targets may be entered for each output variable. Targets are entered in the top row of the scenario analysis window (labeled **Scenario=**) or in the Scenarios section of the Detailed Statistics window. Targets are preceded by a >, <, >=, <= operator and can be specified in terms of percentiles or actual values.

Scenario Analysis:2											
Display Groups of Input Values causing Output Scenarios, using:											
Percentile Medians											
	Cell	Name	C22 / Net Income Percentile	C22 / Net Income Percentile	C22 / Net Income Percentile	D22 / Net Income Percentile	D22 / Net Income Percentile	D22 / Net Income Percentile	E22 / Net Income Percentile	E22 / Net Income Percentile	E22 / Net Income Percentile
		Scenario=	>75%	<25%	>90%	>75%	<25%	>90%	>75%	<25%	>90%
#1	F25	Number of Competitors	--	100%	34%	--	--	--	--	--	--
#2	G25	Number of Competitors	--	--	--	--	--	100%	--	--	--
#3	H25	Number of Competitors	--	--	--	--	--	--	--	--	--
#4	I25	Number of Competitors	--	--	33%	--	100%	--	--	33%	--
#5	J25	Number of Competitors	--	--	--	--	--	--	--	--	--
#6	K25	Number of Competitors	34%	--	--	34%	--	--	--	--	--
#7	L25	Number of Competitors	--	--	100%	--	--	--	--	--	--
#8	E32	Sales Volume	--	--	19.5%	--	--	--	87%	12.5%	94.5%
#9	F32	Sales Volume	--	--	--	--	--	--	--	--	--
#10	G32	Sales Volume	--	--	--	--	--	--	--	--	--
#11	H32	Sales Volume	--	--	--	--	--	--	--	--	82.28587%

What is Scenario Analysis?

Scenario analysis allows you to determine which input variables contribute significantly towards reaching a goal. For example, which variables contribute to exceptionally high sales? Or, which variables contribute to profits below \$1,000,000?

@RISK allows you to define target scenarios for each output. You might be interested in the highest quartile of values in the Total Sales output, or the value less than 1 million in the Net Profits output. Enter these values directly in the Scenarios row of the @RISK Scenario Analysis window to study these situations.

When you display a scenarios window, @RISK looks at the data created by your @RISK simulation. For each output, the following steps are followed:

- 1) The median and standard deviation of the samples for each input distribution for the entire simulation are calculated.
- 2) A "subset" is created containing only the iterations in which the output achieves the defined target.
- 3) The median of each input is calculated for the subset of data.

- 4) For each input, the difference between the simulation median (found in step 1) and the subset median (found in step 3) is calculated and compared to the standard deviation of the input data (found in step 1). If the absolute value of the difference in medians is greater than 1/2 a standard deviation then the input is termed "significant"; otherwise the input is ignored in the scenario analysis.
- 5) Each significant input found in step 4 is listed in the scenario report.

Interpreting the Results

From the above explanation, you know that the scenario report will list all input variables that are "significant" toward reaching a defined goal for an output variable. But what exactly does that mean?

For example, @RISK may tell you that the Retail Price input is significant when studying the highest quartile of Total Sales. So, you know that when Total Sales are high, the median Retail Price is significantly different than the median Retail Price for the whole simulation.

@RISK calculates three statistics for each significant input distribution in a scenario:

- **Actual Median of Samples in Iterations Meeting Target.** The median of the subset of iterations for the selected input (calculated above in step 3). You can compare this to the median of the selected output for the whole simulation (the 50% percentile reported in the statistics report).
- **Percentile Median of Samples in Iterations Meeting Target.** The percentile value of the subset median in the distribution generated for the whole simulation (equivalent to entering the subset median as a Target Value in the @RISK statistics report). If this value is less than 50%, the subset median is smaller than the median for the whole simulation, if it is greater than 50% the subset median is greater than the median for the whole simulation.

You might find that the subset median for Retail Price is lower than the median for the whole simulation (thus the percentile is less than 50%). This indicates that a lower Retail Price can help you reach the goal of high Total Sales.

- **Ratio Shown Median to Original Standard Deviation.** The difference between the subset median and the median for the whole simulation, divided by the standard deviation of the input for the whole simulation. A negative number indicates that the subset median is smaller than the median for the whole simulation, a positive number indicates that the subset median is greater than the median for the whole simulation. The larger the magnitude of this ratio, the more "significant" the variable is in reaching the defined target.

Perhaps another input variable, Number of Salespeople, is significant towards reaching the target of high Total Sales. But, its ratio of median to standard deviation is only half the magnitude of the ratio for the Retail Price input. You could conclude that, while the Number of Salespeople does affect your goal of high Total Sales, the Retail Price is more significant and may require more attention.

Caution: The greatest danger in using scenario analysis is that the analysis results may be deceiving if the subset contains a small number of data points. For example, in a simulation of 100 iterations and a scenario target of ">90%," the subset will contain only 10 data points!

Simulation Menu

Settings Command

Changes the settings which control the simulations performed by @RISK



Settings Icon

The Simulation menu Settings command affects the tasks performed during a simulation. For more information on the available simulation settings, see the **Simulation menu Settings Command** in the section **@RISK Add-In Menu Commands** in this chapter.

Start Command

Starts a Simulation



Start Icon

The Simulate menu Start command (or clicking the Simulate icon) starts a simulation using the current settings.

Results Menu

Real-Time Results Command

Selects whether or not simulation results will be updated real-time as the simulation runs and specifies the interval for updating

Simulation results can be updated in the Results window as a simulation runs. Graphs of simulation results and some report windows can be updated during simulation. If **Real-Time Update of @RISK Results Window** is selected on the Monitor tab in the Simulation Settings dialog, the Results window will automatically be displayed when a simulation starts and the updating of open windows will begin. A Real-Time Results toolbar is displayed that allows you to control the updating of displayed reports and graphs and pause and stop a running simulation.

Real-Time Results Toolbar



The Real-Time Results toolbar is displayed in the Results window whenever a simulation is running. Using the options on this toolbar you can control whether or not reports and graphs are updated as a simulation runs, the interval (in iterations) between updates, whether convergence monitoring is performed, and pause or stop a simulation. The icons and options available in the Real-Time Results toolbar are as follows:

- **Run, Pause and Stop.** Causes a running simulation to pause or stop, or resumes a paused simulation.
- **Enable/Disable Convergence Monitoring.** Turns convergence monitoring off or resumes convergence monitoring. Only available when the **Monitor Convergence** option is selected on the Monitor tab in the Simulation Settings dialog.
- **Enable/Disable Real-Time Results Updating.** Turns real-time updating of simulation results on or off. This option can be selected regardless of the Real-Time Update of @RISK Results Window selection in the Simulation Settings dialog box.

***What Can Be
Performed
While a
Simulation is
Running?***

***Updating
Graphs and
Reports
Simulation to
Simulation***

- **Update Every XXX Iterations.** Specifies the interval between updates of displayed graphs, reports and convergence monitoring. As updating adds to simulation runtime, set the interval to a higher number of iterations if a large number of reports and graphs are updated real-time.

While a simulation is running, you can manipulate graphs, move delimiters, and create new graphs and reports, just as you can do when a simulation is complete. Some reports, such as full Sensitivity and Scenario analysis reports (displayed when the Insert menu Sensitivities or Scenarios commands are selected), are not updated real-time as they typically take longer to generate and this would unduly slow a simulation.

If the same model is re-simulated, @RISK keeps your graph and report windows open simulation to simulation. By doing this you can keep the same graphs, with the same format and scaling, between runs, just changing the data displayed. However, if you add new distributions to your model or add new outputs, @RISK will close all open reports and graphs. You will need to recreate graphs and reports, either while the simulation is running or after the run is complete.

Convergence Monitoring Command

Turns Convergence Monitoring On and Off

The Results menu Convergence Monitoring command turns convergence monitoring off and back on. This command is only available when the **Monitor Convergence** option is selected in the Simulation Settings dialog. For more information on Convergence Monitoring, see **Convergence Monitoring** in the **@RISK Add-In Menu Simulation Settings Command** in this Reference chapter.

Filter Command

Filters values from simulation statistics calculations and graphs

Filters may be entered for each selected output cell or sampled input probability distribution. Filters allow you to remove unwanted values from the statistics calculations and graphs generated by @RISK. Filters are entered using the Filter dialog box or, alternatively, in the Detailed Statistics window in the three Filter entry rows.

Filter Dialog

	Name	Cell	Type	Minimum	Maximum
Output 1	Net Income	C22	Std	-Infinity	-100000
Output 2	Net Income	D22	Off		
Output 3	Net Income	E22	Off		
Output 4	Net Income	F22	Off		
Output 5	Net Income	G22	Off		
Output 6	Net Income	H22	Std	125000	+Infinity
Output 7	Net Income	I22	Off		
Output 8	Net Income	J22	Off		

Current: Net Income C22: Min=-162655.8 Mean=-39956.69 Max=-35982.14

☐ Show Only Outputs or Inputs with Filters
☐ Same Filters for all Simulations

Clear Filters Cancel Apply

A filter can be defined for any simulation output or sampled input distribution, as listed in the **Name** column of the Filter Settings table. When entering a filter, a **type**, a **minimum** allowed value, **maximum** allowed value or minimum-maximum range may be entered. If the Filter **Minimum** or Filter **Maximum** entry is left blank, the Filter range will be unbounded on one end — allowing a filter with only a maximum or minimum, such as "process only values equal to or above a minimum of 0".

Filter Dialog Options

- **Show Only Outputs or Inputs With Filters** – In the Filter dialog, displays only those outputs or inputs for which filters have been entered.
- **Same Filter For All Simulations** – If multiple simulations have been run, the Same Filter For All Simulations option copies the first filter entered for an input or output to the results for the same input or output in all other simulations.
- **Apply** - Filters are applied as soon as you click the **Apply** button in the Filter dialog box.

- **Clear Filters** - To remove all current filters, click the **Clear Filters** button to remove the filters from the table and then click Apply. To simply disable a filter but leave the entered filter range, set the Filter **Type** to **Off**.

Filter Types

The available Filter Types are:

- **Standard Filter (Std)** — This type of filter is applied only to the output cell or sampled input probability distribution for which the filter was entered. Values below the entered minimum or above the entered maximum are removed from the statistics, sensitivity and scenario calculations for the result and not included in generated graphs for the simulation result.
- **Iteration Filter (Iter)** — This type of filter affects all simulation results. In processing a global iteration filter, first @RISK applies the filter to the output cell or sampled input probability distribution for which the filter was entered. Values below the entered minimum or above the entered maximum are removed from the statistics, sensitivity and scenario calculations for the result and not included in generated graphs for the simulation result. The iterations which satisfy the conditions of this filter for the output or input are then "marked" and all other output cells or sampled input probability distributions are filtered to include only values generated in these iterations. This type of filter is especially useful when you want to review simulation results (for all outputs and inputs) for only those iterations which meet a specific filter condition — such as where "Profit > 0".

Fit Command

Fits probability distributions to the simulation data collected for an output or sampled input.

The Results menu Fit command uses the fitting features of the @RISK – Model window to fit probability distributions to the simulation data collected for an output or a sampled input. This allows the comparison of simulation results to theoretical probability distributions.

When the Results menu Fit command is selected (or an output or sampled input is “right-clicked” in the Explorer list and Fit is selected from the pop-up menu) the data collected for the output or input is transferred to a new Fit tab in the model window and a fit is performed using the default settings for distribution fitting. The fit results are displayed in a Fit Results window.

Report Settings Command

Specifies the location (Results window or Excel) that simulation results will be displayed and the type of reports that will be generated in Excel

The Results Report Settings command specifies the location and type of simulation reports that will be generated. For more information, see **the Results Report Settings Command** in the **@RISK Add-In Menu Commands** section of this chapter.

Graph Menu

Format Graph Command

Changes the appearance of the selected graph

The Graph menu Format Graph command allows you to change the appearance of the active graph. Use this command to change the type, scaling, style and titles of your graphs, turn delimiters on and off and add overlays.

Save as Default

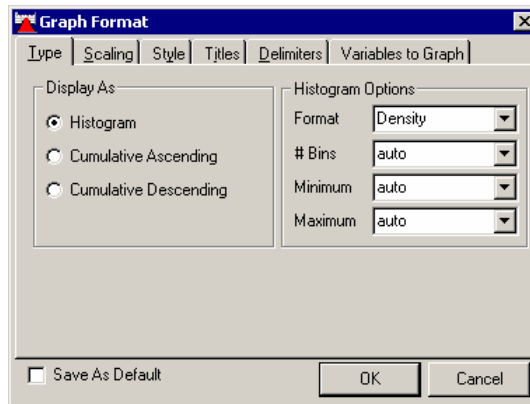
Clicking Save as Default sets the current format settings as the default for the appropriate graph type (probability distribution or Summary). All new graphs of the relevant type generated will use this default.

Type Tab – Graph Format Command

Changes the type and format of a displayed @RISK graph

The Type tab on the Graph Settings dialog box allows you to change the type of a displayed graph. The options which are available when the Type command is selected depend on the graph being edited — standard probability distribution graph or summary graph. For Tornado graphs no Type options are available.

**Type Tab for
Probability
Distribution
Graphs**



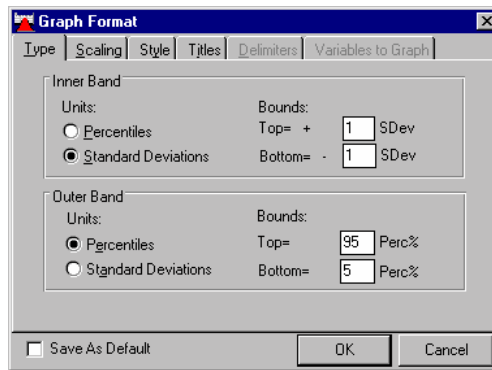
- **Display As.** Changes the displayed distribution from a histogram format to a cumulative ascending or descending format. This option is displayed only for probability distribution graphs (either simulation results for output cells or sampled input distributions).
- **Format.** Selects **Density** or **Relative Freq.** as the unit of measure reported on the Y-axis. Relative Frequency is the probability of a value in the range of a bin occurring (observations in a bin/total observations). Density is the relative frequency value divided by the width of the bin, insuring that Y-axis values stay constant as the number of bins is changed.
- **# Bins.** Sets the number of histogram intervals calculated across the range of a graph. The value entered must be in the range 1 to 200. The setting **Auto** calculates the best number of bins to use for your data is based on an internal heuristic.
- **Minimum.** Sets the minimum value where histogram bins start. **Auto** specifies that @RISK will start the histogram bins based on the minimum of the data graphed. **Auto (Graph Axis)** specifies that bins will start at the minimum value set on the X-axis, (except when the minimum data value is greater than the minimum X-axis value; in this case bins start at the minimum data value).

- **Maximum.** Sets the maximum value where histogram bins end. **Auto** specifies that @RISK will end the histogram bins based on the maximum of the data graphed. **Auto (Graph Axis)** specifies that bins will start at the maximum value set on the X-axis, (except when the maximum data value is less than the maximum X-axis value; in this case bins start at the maximum data value).

Note: the setting Auto (Graph Axis) causes histogram binning to act just as binning was performed (by default) in versions of @RISK earlier than 4.5. This setting causes histograms to automatically rebin to the graph scale range as rescaling is performed, "zooming in" on your data. The setting Auto in @RISK 4.5 does not rebin as rescaling is performed; perserving graph bins regardless of X-axis scaling.

Type Tab for Summary Graphs

The options for Summary graphs allow you to review and change the settings for the bands shown on the Summary graph. The values shown for both inner and outer bands may be set.



Units and Bounds

A Summary Graph displays the trend of mean values for distributions in an output range, surrounded by a band above and below the mean. The "width" of the band is set by the values entered for Summary Inner and Outer Bands using the Type options. Each band may be specified in terms of:

- **Percentiles** (Perc%) or
- **Standard Deviations** (SDev).

For both percentiles and standard deviations an entry is made for the top band (+, or above the mean) and the bottom band (-, or below the mean). The default value for the inner band is +1 standard deviation above the mean and -1 standard deviation below the mean. The default value for the outer band is 95th and 5th percentiles, with the 95th percentile lying above the mean and the 5th percentile lying below it.

**Entering
Summary Graph
Band Values**

To enter a band in terms of Percentiles:

- 1) Click the Percentiles button
- 2) Enter a value between 50 and 100 for the Top entry and between 0 and 50 for the Bottom entry

To enter a band in terms of Standard Deviations

- 1) Click the Standard Deviations radio button
- 2) Enter a value between 0 and 5 for each of the Top + and Bottom - entries. The Top + and Bottom - values do not have to be the same.

Different types of entries — either Percentiles or Standard Deviations — may be used for each band.

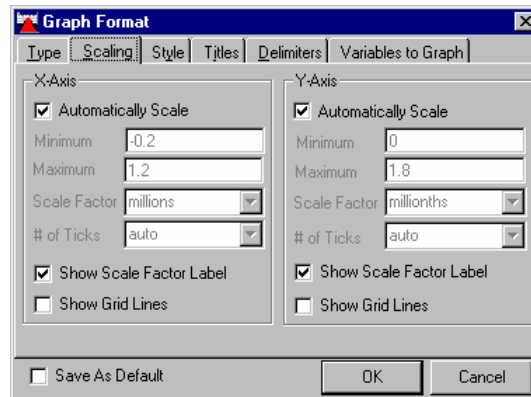
When generating a Summary graph, @RISK calculates the mean and the four band values (such as +/-1 standard deviation and the 5th and 95th percentile) for each cell in the output range graphed. These points are graphed with hi-lo lines, along with interpolated intermediate points between each of the cells in the range.

Scaling Tab – Graph Format Command

Changes the scaling, units and axis tick marks on the active graph

The available Scaling options are affected by whether the displayed graph is for a *probability distribution* (simulation results for output cells or input distributions) or a *summary graph*.

Note: X-axis scaling on a probability distribution graph can also be changed by dragging the delimiters at the X-axis endpoints using the mouse, directly on the graph.



- **Automatically Scale.** Specifies that @RISK will automatically calculate X or Y axis minimum and maximum values based on the range and probabilities of the data displayed in the graph.

Note: Clicking the AutoScale button in the top right corner of a graph selects the Automatically Scale option and rescales the graph.

- **X-Axis Maximum.** Enters the X-Axis maximum value for the current graph.
 - 1) **For a probability distribution graph** — Specifies the maximum value shown on the horizontal X-axis of the displayed graph. Values are entered in terms of actual values with all digits. Using the current scale factor, @RISK converts those values to the appropriate units (in thousands, in millions, etc.) for display. X-axis scaling may be adjusted to include all of a distribution or just a portion of it. This allows you to view only a piece of a distribution when more detail is desired.
 - 2) **For a Summary graph** — Specifies the first cell in an output range to include in the Summary graph. For example, if there are 10 cells in an output range, a Summary graph including all 10 will have an X-minimum of 1 and an X-maximum of 10. Changing the X-minimum to 5 would cause only the last 5 cells in the output range to be displayed in the Summary graph.
- **X-Axis Minimum.** Enters the X-axis minimum value for the current graph. Information given for the X-maximum option also applies to X-minimum.
- **Y-Axis Maximum.** Enters the Y-axis maximum value for the current graph.
 - 1) **For a histogram or cumulative graph** — Specifies the maximum probability value displayed on the Y-axis. This value should be greater than zero and less than or equal to one.
 - 2) **For a Summary graph** — Specifies the Y-axis maximum value for the current graph. Information provided for the Summary graph Y-axis minimum also applies here.

- **Y-Axis Minimum.** Enters the Y-axis minimum value for the current graph.
 - 1) **For a histogram or cumulative graph** — No entry possible. The Y-axis minimum is always set to zero.
 - 2) **For a Summary graph** — Specifies the Y-axis minimum value for the current graph. Values are entered in terms of actual values with all digits. Using the current scale factor, @RISK converts those values to the appropriate units (in thousands, in millions, etc.) for display. Y-axis scaling may be adjusted to include all of a Summary graph or just a portion of it. This allows you to view only a piece of a Summary graph when more detail is desired.
- **# of Ticks.** Defines the number of ticks drawn on the X-Axis or Y-axis between the origin and the extreme values.
- **Scale Factor.** Sets the factor used in displaying units on the X- and Y-axis in @RISK graphs. Factors are entered as the listed unit names (thousands, millions, etc.) or as powers of 10. Scale factor entries apply to the X and Y-axis scaling of histogram and cumulative curves and the Y-axis scaling of Summary graphs.

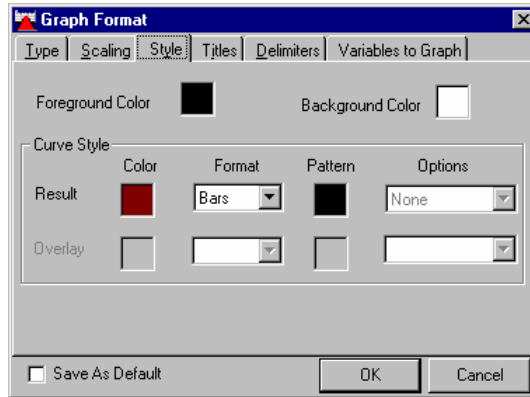
When @RISK initially scales a graph it calculates a default scale factor based on the magnitude of the values displayed in the graph. Entering a new scale factor causes the units displayed (i.e., in thousands, in millions, etc.) to change.

- **Show Scale Factor Label.** Specifies that the scale factor will be labeled on the X and Y axes.

Style Tab – Graph Format Command

Changes the color, format and pattern of elements in the displayed graph

The Style tab in the Graph Format dialog box change the colors, format and patterns on a displayed graph.



Foreground and Background Color

The Foreground and Background Color options set the color of the foreground and background elements in the displayed graph. Colors can be selected by clicking on the box to the right of the **Color** entry.

Curve Style

The **Curve Style** options change the color, format, pattern and other options of the current graph and its overlays. The **Format**, **Pattern** and **Options** available change with the type of the graph displayed.

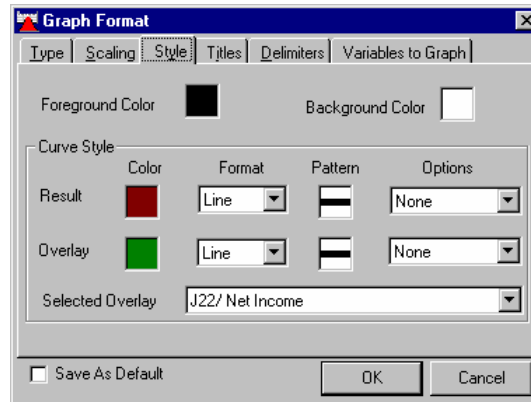
Combined **Format** and **Options** settings include:

- **Points Format.** Graphs unconnected points at midpoint of top of histogram bars or at each point on a cumulative curve. No Options available.
- **Line Format.** Graphs outlined histogram bars (*Graph Type-Histogram; Option-None*), cumulative line graph (*Graph Type-Cumulative; Option-None*), connected midpoints (*Graph Type-Histogram; Option-Link Midpoints*) or fitted curve (*Graph Type-Histogram; Option-Fitted Curve*)
- **Bars Format.** Graphs standard histogram bars. (*Graph Type-Histogram; No Options available*).
- **Filled Format.** Graphs unseparated histogram bars (*Graph Type-Histogram; Option-None*), area graph using midpoints of each class (*Graph Type-Histogram; Option-Link Midpoints*), filled cumulative graph (*Graph Type-Cumulative; Option-None*) or fitted curve (*Graph Type-Histogram; Option-Fitted Curve*)

Selected Overlay

Pattern options include a variety of available line, point and fill patterns.

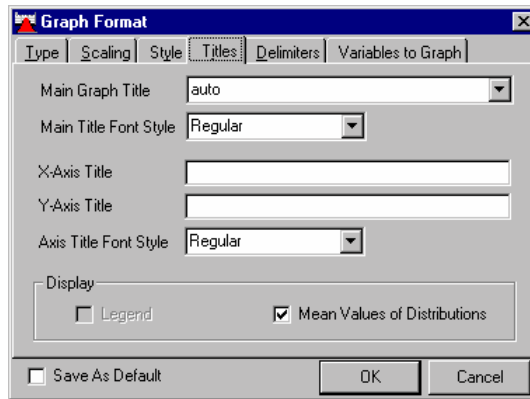
When overlays are present, the **Overlay** entry displays the color, format, pattern and options for the overlay graph for the output listed in **Selected Overlay**. By changing the selected overlay entry you can switch between editing the curve style of the different overlays present on a graph.



Titles Tab – Format Command

Allows the entry of custom titles for a graph

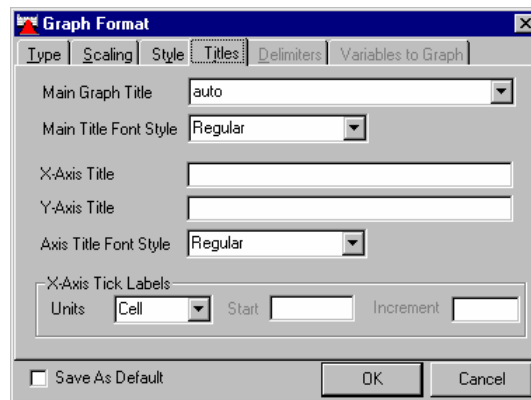
The Titles tab allows the entry of a custom title for any graph, along with custom X- and Y-axis legends. Font style may also be set for titles.



- **Graph and Axis Titles.** Changes a selected title. Titles may also be formatted using any of the font styles listed in the dropdown font style entries. The Auto entry specifies that @RISK will automatically generate a graph title for you.
- **Display.** Adds or removes the @RISK-generated labels on graphs - **Legend** (graphs with overlays only) and **Expected Value**.

Text and graphics may also be placed on graphs using the drawing and text editing capabilities of your spreadsheet. Using the @RISK Edit menu Copy command, the active graph can be transferred to the Clipboard where it can be pasted into your spreadsheet as a Windows Metafile. Once pasted, the graph can be resized and text and graphics may be attached to it.

Summary Graph Titles Tab



The image shows the 'Graph Format' dialog box with the 'Titles' tab selected. The dialog has several tabs: 'Type', 'Scaling', 'Style', 'Titles' (active), 'Delimiters', and 'Variables to Graph'. The 'Titles' tab contains the following fields and options:

- Main Graph Title:** A dropdown menu currently set to 'auto'.
- Main Title Font Style:** A dropdown menu currently set to 'Regular'.
- X-Axis Title:** An empty text input field.
- Y-Axis Title:** An empty text input field.
- Axis Title Font Style:** A dropdown menu currently set to 'Regular'.
- X-Axis Tick Labels:** A section containing:
 - Units:** A dropdown menu currently set to 'Cell'.
 - Start:** An empty text input field.
 - Increment:** An empty text input field.

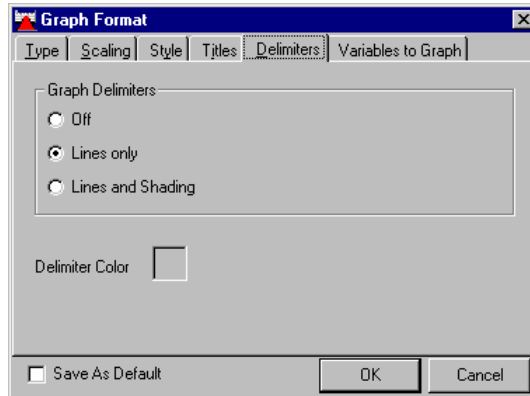
At the bottom of the dialog, there is a checkbox labeled 'Save As Default', and 'OK' and 'Cancel' buttons.

A summary graph has additional options for labeling the tick marks on the X-axis. The **Units** entry specifies the units used for the tick labels (either **Cell**, **Name**, **Years**, **Months** or any custom units type you wish to enter). **Units** are labeled to the left of the X-axis on the graph. If **Name** is used for Units @RISK will label each X-axis tick with the name of the output cell associated with the tick on the graph. If you wish to use **Name** for units you should enter short output names so they can be displayed on the graph. The **Start** entry specifies the value for the first axis tick and the **Increment** entry specifies the increment between ticks.

Delimiters Tab – Graph Format Command

Selects the display mode for delimiters on a histogram graph or cumulative graph.

Delimiters can be displayed on histogram graphs or cumulative graphs to allow 1) the setting of target probabilities directly on a graph and 2) X-axis rescaling. Delimiters are marked by inverted triangles at the top of a graph.



Delimiters can be turned on and off as desired and shading between delimiters can be displayed or removed. The color of delimiters and their associated shading can be specified by clicking on the box to the right of the **Delimiter Color** entry.

Using Delimiters

To move delimiters:

- 1) Click and drag any of the four delimiters marked by an upside-down triangle at the top of the graph to the desired location. Moving probability delimiters also updates the **Left X**, **Left P**, **Right X**, **Right P**, **X(diff)** and **P(diff)** in the displayed Statistics tab. The **diff** statistics show the value and probabilities falling between the left and right probability delimiters.

Note: If you hold down the <Ctrl> key while dragging delimiters, delimiters will move a much smaller increment each time they change position.

Variables To Graph Tab – Graph Format Command

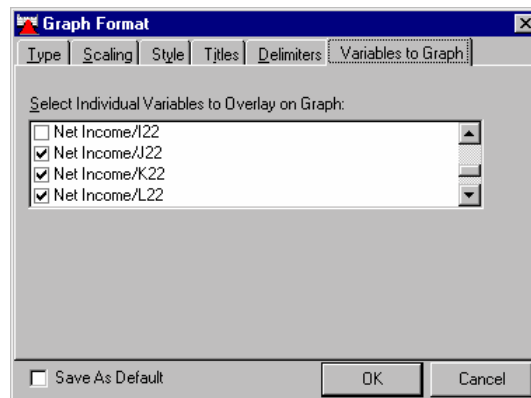
Selects the input variables to display on a histogram graph, cumulative graph or Tornado graph

The Variables to Graph tab allows multiple distributions to be overlaid on a histogram or cumulative graph. In addition, the Variables to Graph tab allows the customization of Tornado graphs to show only those input distribution sensitivities you are interested in.

Note: A shortcut method for creating overlay graphs is to use the Overlay on Active Graph command from the Explorer list right-click pop-up menu.

Overlay Graphs

When a simulation output is initially graphed, the distribution of possible results for that output alone is displayed in a new graph window using the default graph type. By using the Variables to Graph tab, additional outputs may be added to the graph or currently overlaid outputs may be removed from the graph.

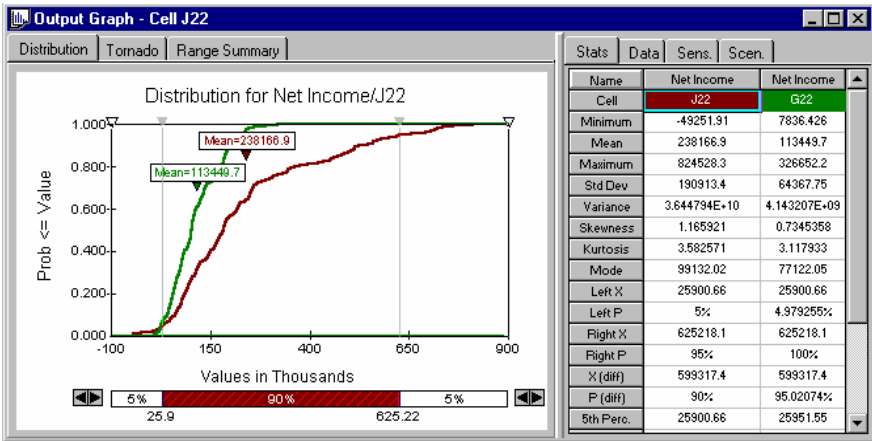


Selecting Inputs to Display in a Histogram or Cumulative Graph

To select or deselect output variables whose distributions will be overlaid on the current graph:

- 1) When a histogram or cumulative graph is displayed and active, select the **Graph menu Graph Format** command and then select the **Variables to Graph** tab.
- 2) Highlight those inputs you wish to overlay on the graph by holding down the <Ctrl> key while clicking on the variable names with the mouse. Clicking on an already highlighted output deselects it.

Cumulative
Curve
Overlays



Overlay graphs are displayed in the same format as the initially displayed graph. However, the graph style of any displayed curve may then be changed using the Graph Format dialog settings. @RISK will initially rescale your graph when overlays are added, based on the maximum X and Y values in all distributions being graphed. Once graphed, however, scale values may be changed as needed using Graph Format dialog Scaling options.

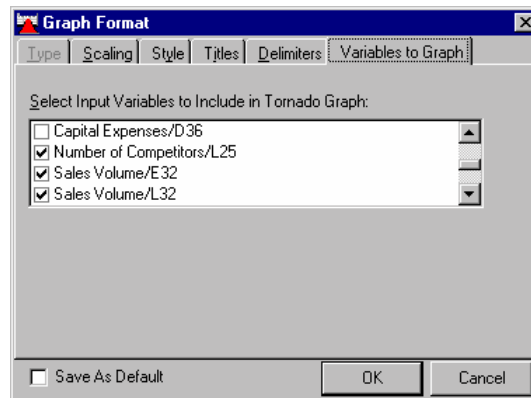
Comparing
Results with
Overlays

Overlays are especially useful for comparing output distributions in cumulative format. This comparison shows which outputs have higher probabilities at various points across the X-scale range. As delimiters are moved on overlay graphs target probabilities are updated for each included distribution. The probability bar at the bottom of the graph continues to return values for the primary curve. Comparisons may also be made for outputs in different simulations when multiple simulations are run.

Note: A maximum of ten outputs may be overlaid on a single graph.

Variables to Graph-Simulation Sensitivity Tornado Graphs

The Variables to Graph tab allows the customization Tornado graphs to show only those input distribution sensitivities you are interested in. By default, @RISK displays a tornado bar for each input distribution with a non-zero coefficient value, up to a maximum of 15 inputs. By using the Variables to Graph tab, bars may be removed from the tornado graph.



Selecting Inputs to Display in a Tornado Graph

To select or deselect input variables whose bars will be displayed in a Tornado graph:

- 1) When a Tornado graph is displayed and active, select the **Graph Format** dialog **Variables to Graph** tab.
- 2) Highlight those inputs you wish to include in the Tornado graph by holding down the <Ctrl> key while clicking on the variable names with the mouse. Clicking on an already highlighted input deselects it.

Graph Type Command

Changes the type of the current graph

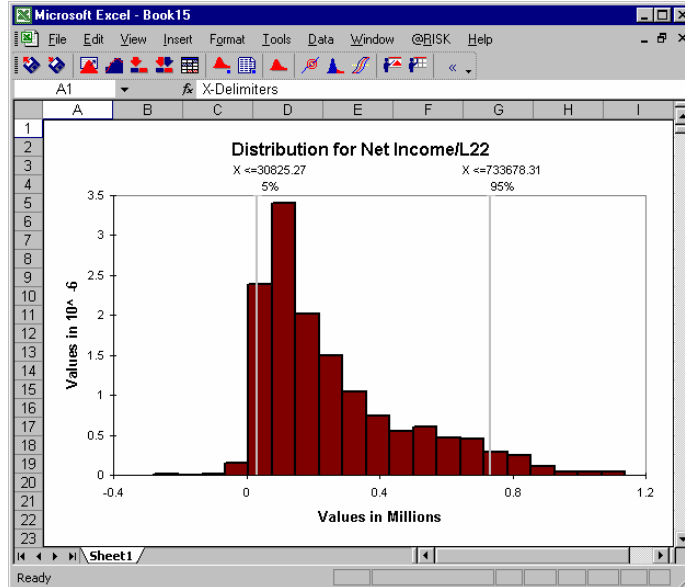
The Graph menu Graph Type command quickly changes the type and style of a histogram or cumulative graph. Using the icons on the Graph Toolbar, the type of an active graph may be quickly changed. Graph Type may also be changed using the Graph Format command. The available types include:

- 1) **Histogram.** Selects a histogram or a "relative frequency" distribution for the current output cell. Three formats for a histogram are available through the Graph Type command:
 - **Bar Graph.** Selects bar format for the current graph. In bar format each bin in a distribution is represented by a bar that has a height corresponding with the probability density value for the bin.
 - **Area Graph.** Selects an area graph where probability density values are connected by line segments and the area under the curve is filled solid. Points representing histogram bar heights are located at the midpoint of each bar.
 - **Fitted Curve.** Selects a fitted curve where a cubic spline fit is generated for the midpoint probability density values for the bars in the histogram. This spline fit is then displayed in filled format.
- 2) **Cumulative Ascending.** Selects a graph of ascending cumulative probabilities. A point on an ascending cumulative curve shows the probability that a random value will be less than or equal to the associated value on the horizontal X-axis. For example, at the distribution maximum, the probability is 100% as there is a 100% chance of a value less than or equal to the distribution maximum occurring. Cumulative graphs can be displayed as lines or filled.
- 3) **Cumulative Descending.** Selects a graph of descending cumulative probabilities. A point on the descending cumulative distribution shows the probability that a random value will be at least as great as the value shown on the horizontal X-axis. For example, at the distribution maximum, the probability is 0% as there is a 0% chance of a value greater than the distribution maximum occurring. Cumulative graphs can be displayed as lines or filled.

Graph in Excel Command

Draws the selected graph in Microsoft Excel in the spreadsheet's native format

The Graph menu Graph in Excel command places the selected graph data points in an Excel worksheet. Then, a native format graph is created on the worksheet from the data points.



Once the graph is created, it can be customized and rescaled using Excel's editing features. Please consult your spreadsheet's documentation for more information on editing the graphs.

For histograms, bar heights can be changed directly in Excel by changing the relevant series data.

Delimiter Defaults Command

Specifies the position of the left and right delimiters for all histogram and cumulative graphs

The Graph menu Delimiter Defaults command specifies the starting delimiter positions for new histogram and cumulative graphs. These settings affect all new histogram and cumulative graphs for all simulations run.

Window Menu

Show Excel Window Command

Shows Excel and the @RISK add-in

The Window menu Show Excel Window command shows the Excel window and the @RISK add-in. To show the @RISK Results window again, click the Show Results Window icon in the @RISK toolbar.

Show Model Window Command

Shows the @RISK Model window

The Window menu Show Model Window command shows the @RISK Model window. To show the @RISK Results window again, click the Show Results Window icon in the @RISK toolbar.

Cascade Command, Tile Command

Arranges open windows and graphs in the @RISK Results window

The Window menu Cascade and Tile commands cascade or tile the open windows neatly within the @RISK Results window.

List of Available Windows

Lists all open windows in the @RISK Results window.

The bottom items in the Window menu list all open windows in the @RISK Results window (the active window is noted with a check mark). To activate a window, select its name from the list.

Help Menu

How Do I?

Opens the How Do I guide for @RISK

The Help menu How Do I? command opens the How Do I? guide for @RISK. This contains quick instructions in how to perform many common @RISK tasks.

@RISK Help, Distributions Help

Opens on-line help files for @RISK

The Help menu @RISK Help command opens the main help file for @RISK. All of @RISK's features and commands are described in this file.

The Help menu Distributions Help command opens the distribution help file for @RISK. Information on all of @RISK's distribution functions, including formulas, statistics and graphs, is included in this file.

Online Manual

Opens on-line manual for @RISK

The Help menu Online Manual command opens this manual on-line in PDF format. You must have Adobe Acrobat reader installed to view the online manual.

Authorization Command

Displays authorization information for @RISK and allows the authorization of trial versions

The Help menu Authorization command displays the Authorization dialog box, listing the version and authorization information for your copy of @RISK. Using this dialog box you can also convert a trial version of @RISK into an authorized copy.

About Command

Displays version and copyright information about @RISK

The Help menu About command displays the About dialog box, listing the version and copyright information for your copy of @RISK

Reference: @RISK Functions

Introduction

@RISK includes custom functions that can be included in Excel cells and formulas. These functions are used for:

- 1) **Defining probability distributions** (@RISK *distribution functions* and *distribution property* functions).
- 2) **Defining simulation outputs** (*RiskOutput* function)
- 3) **Returning simulation results to your spreadsheet** (@RISK *statistics* and *graphing* functions)

This reference chapter describes each of these types of @RISK functions and gives details about both the required and optional arguments for each function.

Distribution Functions

Probability distribution functions are used for adding uncertainty — in the form of probability distributions — to the cells and equations in your Excel worksheet. For example, you could enter `RiskUniform(10,20)` to a cell in your worksheet. This specifies that the values for the cell will be generated by a uniform distribution with a minimum of 10 and a maximum of 20. This range of values replaces the single "fixed" value required by Excel.

Distribution functions are used by @RISK during a simulation for sampling sets of possible values. Each iteration of a simulation uses a new set of values sampled from each distribution function in your worksheet. These values are then used in recalculating your worksheet and generating a new set of possible results.

As with Excel functions, distribution functions contain two elements, a function name and argument values which are enclosed in parentheses. A typical distribution function is:

`RiskNormal(100,10)`

A different distribution function is used for each type of probability distribution. The type of distribution which will be sampled is given by the name of the function. The parameters which specify the distribution are given by the arguments of the function.

The number and type of arguments required for a distribution function vary by function. In some cases, such as with:

RiskNormal(mean,standard deviation)

a fixed number of arguments are specified each time you use the function. For others, such as DISCRETE, you specify the number of arguments you desire, based on your situation. For example, a DISCRETE function may specify two possible outcomes, or three, or more as needed.

Like Excel functions, distribution functions may have arguments which are references to cells or expressions. For example:

RiskTriang(B1,B2*1.5,B3)

In this case the cell value would be specified by a triangular distribution with a minimum value taken from cell B1, a most likely value calculated by taking the value for cell B2 and multiplying it by 1.5 and a maximum value taken from cell B3.

Distribution functions also may be used in cell formulas, just as are Excel functions. For example, a cell formula could read:

B2: 100+RiskUniform(10,20)+(1.5*RiskNormal(A1,A2))

All standard Excel editing commands are available to you when entering distribution functions. However, you will need to have @RISK loaded for the distribution functions to be sampled by Excel. If it is not attached, Excel will return the expected value of the function when the worksheet is recalculated.

To enter probability distribution functions:

- 1) Examine your worksheet and identify those cells which you think have uncertain values

Look for those cells where the actual values which occur could vary from those shown in the worksheet. At first, identify those important variables whose cell values may have the largest variation in value. As your Risk Analysis gets more refined, you can further expand your use of distribution functions throughout the worksheet.

- 1) Select distribution functions for the cells you have identified. In Excel, use the Insert menu Function command to enter the selected functions into formulas.

You have over thirty types of distributions to choose from when selecting a distribution function. Unless you know specifically how uncertain values are distributed it is a good idea to start with some of the simpler distribution types — uniform, triangular, or normal. As a starting point, if possible, specify the current cell value as the mean or most likely value of the distribution function. The range of the function you are using then reflects the possible variation around the mean or most likely value.

The simple distribution functions can be very powerful as you can describe uncertainty with only a few values or arguments. For example:

- **RiskUniform(*Minimum, Maximum*)** uses only two values to describe the full range of the distribution and assign probabilities for all the values in the range.
- **RiskTriang(*Minimum, Most Likely, Maximum*)** uses three easily identifiable values to describe a complete distribution.

As your models become more complex, you probably will want to choose from more complex distribution types in order to meet your specific modeling needs. Use the listings in this Reference section to guide you in selecting and comparing distribution types.

A graph of the distribution is often helpful in selecting and specifying distribution functions. You can use **@RISK Define Distribution** window to display distribution graphs and add distribution functions to cell formulas. To do this, select the cell where you wish to add a distribution function and click the Define Distribution icon or the **@RISK** add-in menu Model Define Distribution command. The on-line file displayed when the **@RISK Help menu Distributions Help** command is selected also contains graphic depictions of different functions at selected argument values. For more information on the Define Distribution window, see the **Model Menu: Define Distribution Command** in the **@RISK Add-In Menu Commands** section in this manual.

It often helps to first use the Define Distribution window to enter your distribution functions to better understand how to assign values to function arguments. Then, once you better understand the syntax of distribution function arguments, you can enter the arguments yourself directly in Excel, bypassing the Define Distribution window.

Fitting Data to Distributions

The @RISK Model window (Professional and Industrial versions only) allows you to fit probability distributions to your data. The distributions which result from a fit are then available to be assigned as input distributions and added to your spreadsheet model. By setting the **Source** in the Define Distribution window to **Fit Results**, you can use the fit results from any fit tab for assigning distributions to model inputs. For more information on distribution fitting see the **Fitting Menu Commands** in the **@RISK Model Window Commands** section in this manual.

Distribution Property Functions

Optional arguments to distribution functions can be entered using **Distribution Property** functions. These optional arguments are used to name an input distribution for reporting and graphing, truncate the sampling of a distribution, correlate the sampling of a distribution with other distributions and keep a distribution from being sampled during a simulation. These arguments are not required, but can be added as needed.

Optional arguments specified using @RISK distribution property functions are embedded inside of a distribution function. Distribution Property functions are entered just as are standard Excel functions and can include cell references and mathematical expressions as arguments.

For example, the following function truncates the entered normal distribution to a range with a minimum value of 0 and a maximum value of 20:

=RiskNormal(10,5,RiskTruncate(0,20))

No samples will be drawn outside this minimum-maximum range.

Alternate Parameters

Many distribution functions can be entered by specifying percentile values for the distribution you want. For example, you may want to enter a distribution that is normal in shape and has a 10th percentile of 20 and a 90th percentile of 50. These percentiles may be the only values you know about this normal distribution – the actual mean and standard deviation required by the traditional normal distribution are unknown.

Alternate parameters may be used instead of (or in conjunction with) the standard arguments for the distribution. When entering percentile arguments, the **Alt** form of the distribution function is used, such as **RiskNormalAlt** or **RiskGammaAlt**.

Types of Alternate Parameters

Each parameter to an alternate parameter distribution function requires a pair of arguments in the function. Each pair of arguments specifies:

- 1) The **type of parameter** being entered
- 2) The **value for the parameter**.

Each argument in a pair is entered directly in the Alt function, such as **RiskNormalAlt(arg1type, arg1value, arg2type, arg2value)**. For example:

- **RiskNormalAlt(5%, 67.10, 95%, 132.89)** - specifies a normal distribution with the 5th percentile at the value of 67.10 and the 95th percentile at the value of 132.89.

Alternate parameters may be either percentiles or standard distribution arguments. If a **type of parameter** argument is a label in quotes (such as "**mu**"), the parameter specified is the standard distribution argument that has the entered name. This allows percentiles to be mixed with standard distribution arguments, such as:

- **RiskNormalAlt("mu", 100, 95%, 132.89)** - specifies a normal distribution with a mean of 100 and the 95th percentile at the value of 132.89.

The allowable names for the standard arguments of each distribution can be found in the heading for each function in this chapter, in the Excel Function Wizard in the @RISK Distrib (Alt Param) section, or by using the Define Distribution window. **Note: If you click the Alt icon in the Define Distribution window and select a Standard Argument and click OK, @RISK will write the appropriate name for the standard argument in quotes in the function in the formula bar of the Define Distribution window.**

If a **type of parameter** argument is a value between 0 and 1 (or 0% to 100%), the parameter specified is the entered percentile for the distribution.

**Location or
"loc"
Parameters**

Some distributions will have an additional **location** parameter when they are specified using alternate parameters. This parameter is typically available for distributions that do not have a location value specified in one of their standard arguments. **Location is equivalent to the minimum or 0 perc% value of the distribution.** For example, the Gamma distribution does not have a location value specified through its standard arguments and thus a location parameter is available. The normal distribution, on the other hand, does have a location parameter in its standard arguments – the mean or mu – and thus does not have a separate location parameter when it is entered using alternate parameters. The purpose of this "extra" parameter is to allow you to specify percentiles for shifted distributions. (e.g. a three parameter Gamma with a location of 10 and two percentiles)

**Sampling
Distributions
with Alternate
Parameters**

During a simulation @RISK calculates the appropriate distribution whose percentile values equal those alternate parameter values entered and then samples that distribution. Just like all @RISK functions, the entered arguments may be references to other cells or formulas, just as with any Excel function; and argument values may change iteration to iteration during a simulation.

**Cumulative
Descending
Percentiles**

Alternate percentile parameters to probability distributions may be specified in terms of cumulative descending percentiles as well as the standard cumulative ascending percentiles. Each of the Alt forms for probability distribution functions (such as **RiskNormalAlt**) has a corresponding **AltD** form (such as **RiskNormalAltD**). If the AltD form is used, any entered percentile values are cumulative descending percentiles, where the percentile specifies the chance of a value greater or equal to the entered value.

If you select the @RISK add-in menu **Options command Display Cumulative Descending Percentiles option**, all @RISK reports will show cumulative descending percentile values. In addition, when you click the **Alt icon** in the Define Distribution window to enter distributions using alternate parameters, cumulative descending percentiles will automatically be shown and AltD forms of probability distribution functions will be entered.

In addition to cumulative descending percentiles for alternate parameters distributions, the @RISK cumulative probability distribution (**RiskCumul**) may also be specified using cumulative descending percentiles. To do this, use the function **RiskCumulD**.

Entering Arguments in @RISK Functions

The guidelines for entering Excel functions presented in the relevant User's Guide are also applicable to entering @RISK functions. However, some additional guidelines specific to @RISK functions are:

- Where integer arguments are required by a distribution function, any non-integer argument values will be truncated to integers.
- Integer arguments must be greater than or equal to -32,767 and less than or equal to 32,767. Values outside this range will cause the function to return #VALUE in Excel.
- Distribution functions with varying numbers of arguments (such as HISTOGRM, DISCRETE, and CUMUL) require that arguments of the same type be entered as arrays. Arrays in Excel are denoted by either enclosing the values of the array in {} brackets or using a reference to a contiguous range of cells — such as A1:C1. If a function takes a varying number of value/probability pairs, the values will be one array and the probabilities another. The first value in the value array is matched with the first probability in the probability array and so on.

Optional Arguments

Some @RISK functions have **optional** arguments, or arguments that may be used but are not required. The **RiskOutput** function, for example, has only optional arguments. You can use it with 0, 1 or 3 arguments, depending on what information you wish to define about the output cell where the function is used. You can:

- 1) Just identify the cell as an output, letting @RISK automatically generate a name for you (i.e., =RiskOutput()).
- 2) Give the output a name you select (i.e., =RiskOutput("Profit 1999")).
- 3) Give the output a name you select and identify it as part of an output range (i.e., =RiskOutput("Profit 1999", "Profit By Year", 1)).

Any of these forms of the **RiskOutput** function are allowed because all of its arguments are optional.

When an @RISK function has optional arguments you can add the optional arguments you choose and ignore the rest. You must, however, include all required arguments. For example, for the **RiskNormal** function, two arguments, *mean* and *standard deviation*, are required. All of the arguments which can be added to the RiskNormal function via *distribution property functions* are optional and can be entered in any order you like.

**Important Note
on Excel Arrays**

In Excel, you may not list cell references or names in arrays as you would list constants. For example, you could not use {A1,B1,C1} to represent the array containing the values in cells A1, B1, and C1. Instead, you must use the cell range reference A1:C1 or enter the values of those cells directly in the arrays as constants — for example, {10,20,30}.

- Distribution functions with fixed numbers of arguments will return an error value if an insufficient number of arguments is entered and will ignore extra arguments if too many are entered.
- Distribution functions will return an error value if arguments are of the wrong type (number, array or text).

**More
Information**

This section briefly describes each probability distribution function available and the arguments required for each. In addition, the on-line file displayed when the **@RISK Help menu Distributions Help** command is selected describes the technical characteristics of each probability distribution function. The appendices include formulas for density, distribution, mean, mode, distribution parameters and graphs of the probability distributions generated using typical argument values.

Simulation Output Functions

Output cells are defined using RiskOutput functions. These functions allow the easy copying, pasting and moving of output cells.

RiskOutput functions are automatically added when the standard @RISK Add Output icon is pressed. RiskOutput functions optionally allow you to name your simulation outputs and add individual output cells to output ranges. A typical RiskOutput function might be:

=RiskOutput("Profit")+NPV(.1,H1...H10)

where the cell, prior to its selection as a simulation output, simply contained the formula

= NPV(.1,H1...H10)

The added RiskOutput function selects the cell as a simulation output and gives the output the name "Profit".

Simulation Statistics Functions

@RISK statistics functions return a desired statistic on simulation results. For example, the function *RiskMean(A10)* returns the mean of the simulated distribution for the cell A10. These functions are updated real-time as a simulation is running.

@RISK statistics functions include all standard statistics plus percentiles, targets (for example, *=RiskPercentile(A10,.99)* returns the 99th percentile of the simulated distribution). @RISK statistics functions can be used the way you would use any standard Excel function.

Statistics functions may also reference a simulation output or input by name. This allows them to be included in templates which are used to generate pre-formatted reports in Excel on simulation results. For example, the function *=RiskMean("Profit")* would return the mean of the simulated distribution for the output cell named Profit defined in a model.

Note: A cell reference entered in a statistics function does not have to be a simulation output identified with a RiskOutput function.

Graphing Function

A special @RISK function *RiskResultsGraph* will automatically place a graph of simulation results wherever it is used in a spreadsheet. For example, *=RiskResultsGraph(A10)* would place a graph of the simulated distribution for A10 directly in your spreadsheet at the function's location at the end of a simulation. Additional optional arguments to *RiskResultsGraph* allow you to select the type of graph you want to create, its format, scaling and other options.

Supplemental Functions

Two additional functions — **CurrentIter** and **CurrentSim** — are provided for use in the development of macro-based applications using @RISK. These functions return the current iteration and current simulation, respectively, of an executing simulation.

Limiting Workbooks and Worksheets Searched for @RISK Functions

It is necessary for @RISK to scan open workbooks for its functions both prior to simulating and when the @RISK Model window Outputs and Inputs list is generated. This is very quick for most models but can become time-consuming for larger multi-workbook models. By defining Excel ranges with the name **RiskSearchRange** you can limit the regions of open workbooks which are searched for @RISK functions, speeding up the start of simulations and the display of lists.

RiskSearchRange ranges can be added as either workbook or worksheet level names. Adding RiskSearchRange as an Excel range name has the following effects:

- If a single RiskSearchRange range name is added as a workbook level name, only that single range in the workbook will be searched for @RISK functions .
- If RiskSearchRange range name(s) are added as worksheet level names (i.e. *Sheet1!RiskSearchRange*) in a single workbook, each worksheet-level RiskSearchRange range in the workbook will be searched for @RISK functions.
- If no RiskSearchRange range name is found in a workbook, the entire contents of the workbook will be searched for @RISK functions. This is the default setting for @RISK's function search.

Note: There can be one RiskSearchRange name per sheet in a workbook when worksheet level names are used. For more on the difference between workbook and worksheet-level range names, see your Excel documentation.

Adding a RiskSearchRange

To add a RiskSearchRange:

- 1) Click the Excel Insert menu Name Define command
- 2) Enter the name **RiskSearchRange** and the reference to the range you want @RISK to search. If you want to make your RiskSearchRange name a worksheet level name, simply enter the sheet name prior to the name RiskSearchRange, such as **Sheet1!RiskSearchRange**.

Note: @RISK functions located outside any entered RiskSearchRange will calculate; however, no sampling or correlation settings will be applied to them and they will not be displayed in @RISK Model or Results window lists.

Table of Available Functions

This table lists the custom functions that are added to Excel by @RISK.

Distribution Function	Returns
RiskBeta (<i>alpha1,alpha2</i>)	beta distribution with shape parameters <i>alpha1</i> and <i>alpha2</i>
RiskBetaGeneral (<i>alpha1,alpha2,minimum, maximum</i>)	beta distribution with defined <i>minimum</i> , <i>maximum</i> and shape parameters <i>alpha1</i> and <i>alpha2</i>
RiskBetaGeneralAlt (<i>arg1type, arg1value, arg2type,arg2value, arg3type,arg3value, arg4type,arg4value</i>)	beta distribution with four parameters named <i>arg1type</i> to <i>arg4type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>alpha1</i> ”, “ <i>alpha2</i> ”, “ <i>min</i> ” or “ <i>max</i> ”
RiskBetaSubj (<i>minimum, most likely, mean, maximum</i>)	beta distribution with defined <i>minimum</i> , <i>maximum</i> , <i>most likely</i> and <i>mean</i>
RiskBinomial (<i>n,p</i>)	binomial distribution with <i>n</i> draws and <i>p</i> probability of success on each draw
RiskChiSq (<i>v</i>)	Chi-Square distribution with <i>v</i> degrees of freedom
RiskCumul (<i>minimum,maximum, {X1,X2,...,Xn},{p1,p2,...,pn}</i>)	cumulative distribution with <i>n</i> points between <i>minimum</i> and <i>maximum</i> with cumulative ascending probability <i>p</i> at each point
RiskCumulD (<i>minimum,maximum, {X1,X2,...,Xn},{p1,p2,...,pn}</i>)	cumulative distribution with <i>n</i> points between <i>minimum</i> and <i>maximum</i> with cumulative descending probability <i>p</i> at each point
RiskDiscrete (<i>{X1,X2,...,Xn},{p1,p2,...,pn}</i>)	discrete distribution with <i>n</i> possible outcomes with the value <i>X</i> and probability weight <i>p</i> for each outcome
RiskDuniform (<i>{X1,X2,...,Xn}</i>)	discrete uniform distribution with <i>n</i> outcomes valued at <i>X1</i> through <i>Xn</i>
RiskErf (<i>h</i>)	error function distribution with variance parameter <i>h</i>
RiskErlang (<i>m,beta</i>)	m-erlang distribution with integral shape parameter <i>m</i> and scale parameter <i>beta</i>
RiskExpon (<i>beta</i>)	exponential distribution with decay constant <i>beta</i>

Distribution Function	Returns
RiskExponAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>)	exponential distribution with two parameters named <i>arg1type</i> and <i>arg2type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>beta</i> ” or “ <i>loc</i> ”
RiskExtvalue (<i>a</i> , <i>b</i>)	extreme value (or Gumbel) distribution with location parameter <i>a</i> and scale parameter <i>b</i>
RiskExtvalueAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>)	extreme value (or Gumbel) distribution with two parameters named <i>arg1type</i> and <i>arg2type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>alpha</i> ” or “ <i>beta</i> ”
RiskGamma (<i>alpha</i> , <i>beta</i>)	gamma distribution with shape parameter <i>alpha</i> and scale parameter <i>beta</i>
RiskGammaAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>)	gamma distribution with three parameters named <i>arg1type</i> , <i>arg2type</i> and <i>arg3type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>alpha</i> ”, “ <i>beta</i> ” or “ <i>loc</i> ”
RiskGeneral (<i>minimum</i> , <i>maximum</i> , { <i>X1</i> , <i>X2</i> , ..., <i>Xn</i> }, { <i>p1</i> , <i>p2</i> , ..., <i>pn</i> })	general density function for a probability distribution ranging between <i>minimum</i> and <i>maximum</i> with <i>n</i> (<i>x</i> , <i>p</i>) pairs with value <i>X</i> and probability weight <i>p</i> for each point
RiskGeometric (<i>p</i>)	geometric distribution with probability <i>p</i>
RiskHistogrm (<i>minimum</i> , <i>maximum</i> , { <i>p1</i> , <i>p2</i> , ..., <i>pn</i> })	histogram distribution with <i>n</i> classes between <i>minimum</i> and <i>maximum</i> with probability weight <i>p</i> for each class
RiskHypergeo (<i>n</i> , <i>D</i> , <i>M</i>)	hypergeometric distribution with sample size <i>n</i> , <i>D</i> number of items and <i>M</i> population size
RiskIntUniform (<i>minimum</i> , <i>maximum</i>)	uniform distribution which returns integer values only between <i>minimum</i> and <i>maximum</i>
RiskInvGauss (<i>mu</i> , <i>lambda</i>)	inverse gaussian (or Wald) distribution with mean <i>mu</i> and shape parameter <i>lambda</i>
RiskInvGaussAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>)	inverse gaussian (or Wald) distribution with three parameters named <i>arg1type</i> , <i>arg2type</i> and <i>arg3type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>mu</i> ”, “ <i>lambda</i> ” or “ <i>loc</i> ”
RiskLogistic (<i>alpha</i> , <i>beta</i>)	logistic distribution with location parameter <i>alpha</i> and scale parameter <i>beta</i>

Distribution Function	Returns
RiskLogisticAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>)	logistic distribution with two parameters named <i>arg1type</i> and <i>arg2type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>alpha</i> ” or “ <i>beta</i> ”
RiskLoglogistic (<i>gamma</i> , <i>beta</i> , <i>alpha</i>)	log-logistic distribution with location parameter <i>gamma</i> , scale parameter <i>beta</i> and shape parameter <i>alpha</i>
RiskLoglogisticAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>)	log-logistic distribution with three parameters named <i>arg1type</i> , <i>arg2type</i> and <i>arg3type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>gamma</i> ”, “ <i>beta</i> ” or “ <i>alpha</i> ”
RiskLognorm (<i>mean</i> , <i>standard deviation</i>)	lognormal distribution with specified <i>mean</i> and <i>standard deviation</i>
RiskLognormAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>)	lognormal distribution with three parameters named <i>arg1type</i> , <i>arg2type</i> and <i>arg3type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>mu</i> ”, “ <i>sigma</i> ” or “ <i>loc</i> ”
RiskLognorm2 (<i>mean</i> , <i>standard deviation</i>)	lognormal distribution generated from the “log” of a normal distribution with specified <i>mean</i> and <i>standard deviation</i>
RiskNegbin (<i>s</i> , <i>p</i>)	negative binomial distribution with <i>s</i> successes and <i>p</i> probability of success on each trial
RiskNormal (<i>mean</i> , <i>standard deviation</i>)	normal distribution with given <i>mean</i> and <i>standard deviation</i>
RiskNormalAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>)	normal distribution with two parameters named <i>arg1type</i> and <i>arg2type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>mu</i> ” or “ <i>sigma</i> ”

Distribution Function	Returns
RiskPareto (<i>theta,a</i>)	pareto distribution
RiskParetoAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>)	pareto distribution with two parameters named <i>arg1type</i> and <i>arg2type</i> which can be either a <i>percentile</i> between 0 and 1 or " <i>theta</i> " or " <i>alpha</i> "
RiskPareto2 (<i>b,q</i>)	pareto distribution
RiskPareto2Alt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>)	pareto distribution with two parameters named <i>arg1type</i> and <i>arg2type</i> which can be either a <i>percentile</i> between 0 and 1 or " <i>b</i> " or " <i>q</i> "
RiskPearson5 (<i>alpha,beta</i>)	pearson type V (or inverse gamma) distribution with shape parameter <i>alpha</i> and scale parameter <i>beta</i>
RiskPearson5Alt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>)	pearson type V (or inverse gamma) distribution with three parameters named <i>arg1type</i> , <i>arg2type</i> and <i>arg3type</i> which can be either a <i>percentile</i> between 0 and 1 or " <i>alpha</i> ", " <i>beta</i> " or " <i>loc</i> "
RiskPearson6 (<i>beta,alpha1</i> , <i>alpha2</i>)	pearson type VI distribution with scale parameter <i>beta</i> and shape parameters <i>alpha1</i> and <i>alpha2</i>
RiskPert (<i>minimum</i> , <i>most likely</i> , <i>maximum</i>)	pert distribution with specified <i>minimum</i> , <i>most likely</i> and <i>maximum</i> values
RiskPertAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>)	pert distribution with three parameters named <i>arg1type</i> , <i>arg2type</i> and <i>arg3type</i> which can be either a <i>percentile</i> between 0 and 1 or " <i>min</i> ", " <i>max</i> " or " <i>m. likely</i> "
RiskPoisson (<i>lambda</i>)	poisson distribution
RiskRayleigh (<i>b</i>)	rayleigh distribution with scale parameter <i>b</i>
RiskRayleighAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>)	rayleigh distribution with two parameters named <i>arg1type</i> and <i>arg2type</i> which can be either a <i>percentile</i> between 0 and 1 or " <i>beta</i> " or " <i>loc</i> "
RiskSimtable (<i>{X1,X2,...Xn}</i>)	lists values to be used in each of a series of simulations
RiskStudent (<i>nu</i>)	student's t distribution with <i>nu</i> degrees of freedom
RiskTriang (<i>minimum</i> , <i>most likely</i> , <i>maximum</i>)	triangular distribution with defined <i>minimum</i> , <i>most likely</i> and <i>maximum</i> values

Distribution Function	Returns
RiskTriangAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>)	triangular distribution with three parameters named <i>arg1type</i> , <i>arg2type</i> and <i>arg3type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>min</i> ”, “ <i>max</i> ” or “ <i>m. likely</i> ”
RiskTrigen (<i>bottom</i> , <i>most likely</i> , <i>top</i> , <i>bottom perc.</i> , <i>top perc.</i>)	triangular distribution with three points representing value at <i>bottom percentile</i> , <i>most likely</i> value and value at <i>top percentile</i> .
RiskUniform (<i>minimum</i> , <i>maximum</i>)	uniform distribution between <i>minimum</i> and <i>maximum</i>
RiskUniformAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>)	uniform distribution with two parameters named <i>arg#type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>min</i> ” or “ <i>max</i> ”
RiskWeibull (<i>alpha</i> , <i>beta</i>)	weibull distribution with shape parameter <i>alpha</i> and scale parameter <i>beta</i>
RiskWeibullAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>)	weibull distribution with three parameters named <i>arg1type</i> , <i>arg2type</i> and <i>arg3type</i> which can be either a <i>percentile</i> between 0 and 1 or “ <i>alpha</i> ”, “ <i>beta</i> ” or “ <i>loc</i> ”

Distribution Property Function	Specifies
RiskCollect()	Causes samples to be collected during a simulation for the distribution in which the Collect function is included (when simulation settings specify Collect Samples for Distributions Marked with Collect only)
RiskCorrmat (<i>matrix cell range, position, instance</i>)	Identifies a <i>matrix</i> of rank correlation coefficients and a <i>position</i> in the matrix for the distribution in which the Corrmat function is included. <i>Instance</i> specifies the instance of the matrix at matrix cell range that will be used for correlating this distribution.
RiskDepC (<i>"ID", coefficient</i>)	Identifies dependent variable in correlated sampling pair with rank correlation <i>coefficient</i> and <i>"ID"</i> identifier string
RiskFit (<i>ProjID, FitID, "selected fit result"</i>)	Links a data set identified by <i>ProjID</i> and <i>FitID</i> and its fit results to the input distribution so the input can be updated when data changes
RiskIndepC (<i>"ID"</i>)	Identifies independent distribution in rank correlated sampling pair — <i>"ID"</i> is identifier string
RiskLock()	Blocks sampling of the distribution in which the Lock function is included
RiskName (<i>"input name"</i>)	<i>Input name</i> for the distribution in which the Name function is included
RiskShift (<i>shift</i>)	Shifts the domain of the distribution in which the Shift function is included by <i>shift</i> value
RiskTruncate (<i>minimum, maximum</i>)	<i>Minimum-maximum</i> range allowable for samples drawn for the distribution in which the Truncate function is included
Output Function	Specifies
RiskOutput (<i>"name", "output range name", position in range</i>)	Simulation output cell with <i>name</i> , <i>output range name</i> to which the output belongs, and the <i>position in range</i> (<i>Note: all arguments to this function are optional</i>)

Statistics Function	Returns
RiskData (<i>cellref or output/input name, iteration#, Sim#</i>)	Data value of the simulated distribution for the entered <i>cellref or output/input name</i> in <i>iteration#</i> and <i>Sim#</i>
RiskKurtosis (<i>cellref or output/input name, Sim#</i>)	Kurtosis of the simulated distribution for the entered <i>cellref or output/input name</i> in <i>Sim#</i>
RiskMax (<i>cellref or output/input name, Sim#</i>)	Maximum value of the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i>
RiskMean (<i>cellref or output/input name, Sim#</i>)	Mean of the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i>
RiskMin (<i>cellref or output/input name, Sim#</i>)	Minimum value of the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i>
RiskMode (<i>cellref or output/input name, Sim#</i>)	Mode of the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i>
RiskPercentile (<i>cellref or output/input name, perc%, Sim#</i>)	Percentile <i>perc%</i> of the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i>
RiskPercentileD (<i>cellref or output/input name, perc%, Sim#</i>)	Percentile <i>perc%</i> of the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i> (<i>perc%</i> is a cumulative descending percentile)
RiskRange (<i>cellref or output/input name, Sim#</i>)	Range of the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i>
RiskSkewness (<i>cellref or output/input name, Sim#</i>)	Skewness of the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i>
RiskStdDev (<i>cellref or output/input name, Sim#</i>)	Standard deviation of the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i>
RiskTarget (<i>cellref or output/input name, target value, Sim#</i>)	Ascending cumulative probability of <i>target value</i> in the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i>
RiskTargetD (<i>cellref or output/input name, target value, Sim#</i>)	Descending cumulative probability of <i>target value</i> in the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i>
RiskVariance (<i>cellref or output/input name, Sim#</i>)	Variance of the simulated distribution for <i>cellref or output/input name</i> in <i>Sim#</i>

Supplemental Function	Returns
RiskCurrentIter()	returns the current iteration of the simulation
RiskCurrentSim()	returns the current simulation number
Graphing Function	Returns
RiskResultsGraph (<i>cellRef</i> or <i>output/input name</i> , <i>graphType</i> , <i>xlFormat</i> , <i>leftdelimiter</i> , <i>rightdelimiter</i> , <i>xMin</i> , <i>xMax</i> , <i>xScale</i> , <i>Sim#</i>)	Graph of the simulated distribution for the entered <i>cellref</i> or <i>output/input name</i> in <i>Sim#</i> , displayed using <i>graphType</i> in metafile or <i>xlFormat</i> , with <i>leftdelimiter</i> , <i>rightdelimiter</i> locations for delimiters and <i>xMin</i> , <i>xMax</i> , <i>xScale</i> settings for X-axis.

Reference: Distribution Functions

Distribution functions are listed here with their required arguments. Optional arguments may be added to these required arguments using the **@RISK Distribution Property functions** listed in the next section.

RiskBeta

Description	RiskBeta(alpha1,alpha2) specifies a beta distribution using the shape parameters <i>alpha1</i> and <i>alpha2</i> . These two arguments generate a beta distribution with a minimum value of 0 and a maximum value of 1.
Examples	RiskBeta(1,2) specifies a beta distribution using the shape parameters 1 and 2. RiskBeta(C12,C13) specifies a beta distribution using the shape parameter <i>alpha1</i> taken from cell C12 and a shape parameter <i>alpha2</i> taken from cell C13.
Guidelines	Both <i>alpha1</i> and <i>alpha2</i> must be greater than zero.

RiskBetaGeneral

Description	RiskBetaGeneral(alpha1,alpha2,minimum,maximum) specifies a beta distribution with the defined <i>minimum</i> and <i>maximum</i> using the shape parameters <i>alpha1</i> and <i>alpha2</i> .
Examples	RiskBetaGeneral(1,2,0,100) specifies a beta distribution using the shape parameters 1 and 2 and a minimum value of 0 and a maximum value of 100. RiskBetaGeneral(C12,C13,D12,D13) specifies a beta distribution using the shape parameter <i>alpha1</i> taken from cell C12 and a shape parameter <i>alpha2</i> taken from cell C13 and a minimum value from D12 and a maximum value of from D13.
Guidelines	Both <i>alpha1</i> and <i>alpha2</i> must be greater than zero.

RiskBetaGeneralAlt

Description	RiskBetaGeneralAlt (<i>arg1type, arg1value, arg2type, arg2value, arg3type, arg3value, arg4type, arg4value</i>) specifies a beta distribution with four arguments of the type <i>arg1type</i> to <i>arg4type</i> . These arguments can be either a percentile between 0 and 1 or "alpha1", "alpha2", "min" or "max".
Examples	RiskBetaGeneralAlt("min",0,10%,1,50%,20,"max",50) specifies a beta distribution with a minimum value of 0 and a maximum value of 50, a 10 th percentile of 1 and a 50 th percentile of 20.
Guidelines	Both "alpha1" and "alpha2" must be greater than zero and "max" > "min".

RiskBetaSubj

Description	RiskBetaSubj (<i>minimum, most likely, mean, maximum</i>) specifies a beta distribution with a <i>minimum</i> and <i>maximum</i> value as specified. The shape parameters are calculated from the defined <i>most likely</i> value and <i>mean</i> .
Examples	RiskBetaSubj(0,1,2,10) specifies a beta distribution with a minimum of 0, a maximum of 10, a most likely value of 1 and a mean of 2. RiskBetaSubj(A1,A2,A3,A4) specifies a beta distribution with a minimum value taken from cell A1, a maximum value taken from cell A4, a most likely value taken from cell A2 and a mean value taken from cell A3.
Guidelines	<i>Minimum</i> must be less than <i>maximum</i> . <i>Most likely</i> must be greater than <i>minimum</i> and less than <i>maximum</i> . <i>Mean</i> must be greater than <i>minimum</i> and less than <i>maximum</i> . <i>Most likely</i> must be greater than <i>minimum</i> and less than <i>maximum</i> . <i>Mean</i> must be greater than <i>minimum</i> and less than <i>maximum</i> . If <i>mean</i> is less than $(\text{maximum} + \text{minimum}) / 2$ then <i>most likely</i> must be less than <i>mean</i> . If <i>mean</i> is greater than $(\text{maximum} + \text{minimum}) / 2$ then <i>most likely</i> must be greater than <i>mean</i> . If <i>most likely</i> equals $(\text{maximum} + \text{minimum}) / 2$ then <i>mean</i> must equal <i>most likely</i> .

RiskBinomial

Description	RiskBinomial (n, p) specifies a binomial distribution with n number of trials and p probability of success on each trial. The number of trials is often referred to as the number of draws or samples made. The binomial distribution is a discrete distribution returning only integer values greater than or equal to zero.
Examples	RiskBinomial(5,.25) specifies a binomial distribution generated from 5 trials or "draws" with a 25% probability of success on each draw. RiskBinomial(C10*3,B10) specifies a binomial distribution generated from the trials or "draws" given by the value in cell C10 times 3. The probability of success on each draw is given in cell B10.
Guidelines	The number of trials n must be a positive integer greater than zero and less than or equal to 32,767. Probability p must be greater than or equal to zero and less than or equal to 1.

RiskChiSq

Description	RiskChiSq (v) specifies a Chi-Square distribution with v degrees of freedom.
Examples	RiskChisq(5) generates a Chi-Square distribution with 5 degrees of freedom. RiskChisq(A7) generates a Chi-Square distribution with the degrees of freedom parameter taken from cell A7.
Guidelines	Number of degrees of freedom v must be a positive integer.

RiskCumul

Description	<p>RiskCumul(<i>minimum</i>,<i>maximum</i>,{<i>X1</i>,<i>X2</i>,...,<i>Xn</i>},{<i>p1</i>,<i>p2</i>,...,<i>pn</i>}) specifies a cumulative distribution with <i>n</i> points. The range of the cumulative curve is set by the <i>minimum</i> and <i>maximum</i> arguments. Each point on the cumulative curve has a value <i>X</i> and a probability <i>p</i>. Points on the cumulative curve are specified with increasing value and increasing probability. Any number of points may be specified for the curve.</p>
Examples	<p>RiskCumul(0,10,{1,5,9},{.1,.7,.9}) specifies a cumulative curve with 3 data points and a range of 0 to 10. The first point on the curve is 1 with a cumulative probability of .1 (10% of the distribution values are less than or equal to 1, 90% are greater). The second point on the curve is 5 with a cumulative probability .7 (70% of the distribution values are less than or equal to 5, 30% are greater). The third point on the curve is 9 with a cumulative probability of .9 (90% of the distribution values are less than or equal to 9, 10% are greater).</p> <p>RiskCumul(100,200,A1:C1,A2:C2) specifies a cumulative distribution with 3 data points and a range of 100 to 200. Row 1 of the worksheet — A1 through C1 — holds the values of each data point while row 2 — A2 through C2 — holds the cumulative probability at each of the 3 points in the distribution. In Excel braces are not required when cell ranges are used as entries to the function.</p>
Guidelines	<p>The points on the curve must be specified in order of increasing value ($X1 < X2 < X3, \dots, < Xn$).</p> <p>The cumulative probabilities <i>p</i> for points on the curve must be specified in order of increasing probability ($p1 \leq p2 \leq p3, \dots, \leq pn$).</p> <p>The cumulative probabilities <i>p</i> for points on the curve must be greater than or equal to 0 and less than or equal to 1.</p> <p><i>Minimum</i> must be less than <i>maximum</i>. <i>Minimum</i> must be less than <i>X1</i> and <i>Maximum</i> must be greater than <i>Xn</i>.</p>

RiskCumulD

Description	<p>RiskCumulD(<i>minimum,maximum,{X1,X2,...,Xn},{p1,p2,...,pn}</i>) specifies a cumulative distribution with <i>n</i> points. The range of the cumulative curve is set by the <i>minimum</i> and <i>maximum</i> arguments. Each point on the cumulative curve has a value <i>X</i> and a probability <i>p</i>. Points on the cumulative curve are specified with increasing value and decreasing probability. Probabilities entered are cumulative descending probabilities, or the probability of a value greater than the entered <i>X</i> value. Any number of points may be specified for the curve.</p>
Examples	<p>RiskCumulD(0,10,{1,5,9},{.9,.3,.1}) specifies a cumulative curve with 3 data points and a range of 0 to 10. The first point on the curve is 1 with a cumulative descending probability of .9 (10% of the distribution values are less than or equal to 1, 90% are greater). The second point on the curve is 5 with a cumulative descending probability .3 (70% of the distribution values are less than or equal to 5, 30% are greater). The third point on the curve is 9 with a cumulative descending probability of .1 (90% of the distribution values are less than or equal to 9, 10% are greater).</p> <p>RiskCumulD(100,200,A1:C1,A2:C2) specifies a cumulative distribution with 3 data points and a range of 100 to 200. Row 1 of the worksheet — A1 through C1 — holds the values of each data point while row 2 — A2 through C2 — holds the cumulative probability at each of the 3 points in the distribution. In Excel braces are not required when cell ranges are used as entries to the function.</p>
Guidelines	<p>The points on the curve must be specified in order of increasing value ($X1 < X2 < X3, \dots, < Xn$).</p> <p>The cumulative probabilities <i>p</i> for points on the curve must be specified in order of decreasing cumulative descending probabilities ($p1 \geq p2 \geq p3, \dots, \geq pn$).</p> <p>The cumulative descending probabilities <i>p</i> for points on the curve must be greater than or equal to 0 and less than or equal to 1.</p> <p><i>Minimum</i> must be less than <i>maximum</i>. <i>Minimum</i> must be less than <i>X1</i> and <i>Maximum</i> must be greater than <i>Xn</i>.</p>

RiskDiscrete

Description	RiskDiscrete ($\{X_1, X_2, \dots, X_n\}, \{p_1, p_2, \dots, p_n\}$) specifies a discrete distribution with a number of outcomes equaling n . Any number of outcomes may be entered. Each outcome has a value X and a weight p which specifies the outcome's probability of occurrence. As with the RiskHistogram function, weights may sum to any value — they are normalized to probabilities by @RISK.
Examples	RiskDiscrete ({0,.5},{1,1}) specifies a discrete distribution with 2 outcomes valued 0 and .5. Each outcome has an equal probability of occurrence as the weight for each is 1. The probability of 0 occurring is 50% (1/2) and the probability of .5 occurring is 50% (1/2). RiskDiscrete (A1:C1,A2:C2) specifies a discrete distribution with three outcomes. The first row of the worksheet — A1 through C1 — holds the values of each outcome while row 2 — A2 through C2 — holds the probability "weight" of each occurring.
Guidelines	Weight values p must be greater than or equal to zero, and the sum of all weights must be greater than zero.

RiskDUniform

Description	RiskDUniform ($\{X_1, X_2, \dots, X_n\}$) specifies a discrete uniform distribution with n possible outcomes with an equal probability of each outcome occurring. The value for each possible outcome is given by the X value entered for the outcome. Each value is equally likely to occur. To generate a discrete uniform distribution where every integer in a range is a possible outcome, use the RiskIntUniform function.
Examples	RiskDUniform ({1,2,1,4.45,99}) specifies a discrete uniform distribution with 4 possible outcomes. The possible outcomes have the values 1, 2, 1, 4.45 and 99. RiskDUniform (A1:A5) specifies a discrete uniform distribution with 5 possible outcomes. The possible outcomes have the values taken from cells A1 through A5.
Guidelines	None.

RiskErf

Description	RiskErf(<i>h</i>) specifies an error function with a variance parameter <i>h</i> . The error function distribution is derived from a normal distribution.
Examples	RiskErf(5) generates an error function with a variance parameter 5. RiskErf(A7) generates an error function with a variance parameter taken from cell A7.
Guidelines	Variance parameter <i>h</i> must be greater than 0.

RiskErlang

Description	RiskErlang(<i>m</i>,<i>beta</i>) generates an m-erlang distribution with the specified <i>m</i> and <i>beta</i> values. <i>m</i> is an integer argument for a gamma distribution and <i>beta</i> is a scale parameter.
Examples	RiskErlang(5,10) specifies an m-erlang distribution with an <i>m</i> value of 5 and a scale parameter of 10. RiskErlang(A1,A2/6.76) specifies an m-erlang distribution with an <i>m</i> value taken from cell A1 and a scale parameter equaling the value in cell A2 divided by 6.76.
Guidelines	<i>m</i> must be a positive integer. <i>beta</i> must be greater than zero.

RiskExpon

Description	RiskExpon(<i>beta</i>) specifies an exponential distribution with the entered <i>beta</i> value. The mean of the distribution equals <i>beta</i> .
Examples	RiskExpon(5) specifies an exponential distribution with a beta value of 5. RiskExpon(A1) specifies an exponential distribution with a beta value taken from cell A1.
Guidelines	<i>Beta</i> must be greater than zero.

RiskExponAlt

Description	RiskExponAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>) specifies an exponential distribution with two arguments of the type <i>arg1type</i> and <i>arg2type</i> . <i>arg1type</i> and <i>arg2type</i> can be either a <i>percentile</i> between 0 and 1 or “ <i>beta</i> ” or “ <i>loc</i> ”.
Examples	RiskExponAlt("beta",1,95%,10) specifies an exponential distribution with a beta value of 1 and a 95% percentile of 10.
Guidelines	“ <i>beta</i> ” must be greater than zero.

RiskExtValue

Description	RiskExtValue (<i>a</i> , <i>b</i>) specifies an extreme value distribution with location parameter <i>a</i> and shape parameter <i>b</i> .
Examples	RiskExtvalue(1,2) specifies an extreme value distribution with an <i>a</i> value of 1 and a <i>b</i> value of 2. RiskExtvalue(A1,B1) specifies an extreme value distribution with an <i>a</i> value taken from cell A1 and a <i>b</i> value of taken from cell B1.
Guidelines	<i>b</i> must be greater than zero.

RiskExtValueAlt

Description	RiskExtValueAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>) specifies an extreme value distribution with with two arguments of the type <i>arg1type</i> and <i>arg2type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or “ <i>alpha</i> ” or “ <i>beta</i> ”.
Examples	RiskExtvalueAlt(5%,10,95%,100) specifies an extreme value distribution with a 5 th percentile of 10 and a 95 th percentile of 100.
Guidelines	“ <i>beta</i> ” must be greater than zero.

RiskGamma

Description	<i>RiskGamma</i> (<i>alpha</i> , <i>beta</i>) specifies a gamma distribution using the shape parameter <i>alpha</i> and the scale parameter <i>beta</i> .
Examples	<i>RiskGamma</i> (1,1) specifies a gamma distribution where the shape parameter has a value of 1 and the scale parameter has a value of 1. <i>RiskGamma</i> (C12,C13) specifies a gamma distribution where the shape parameter has a value taken from cell C12 and the scale parameter has a value taken from cell C13.
Guidelines	Both <i>alpha</i> and <i>beta</i> must be greater than zero.

RiskGammaAlt

Description	<i>RiskGammaAlt</i> (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>) specifies a gamma distribution with three arguments of the type <i>arg1type</i> to <i>arg3type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>alpha</i> ", " <i>beta</i> " or " <i>loc</i> ".
Examples	<i>RiskGammaAlt</i> ("alpha",1,"beta",5,95%,10) specifies a gamma distribution where the shape parameter has a value of 1, the scale parameter has a value of 5 and the 95 th percentile has a value of 10.
Guidelines	Both <i>alpha</i> and <i>beta</i> must be greater than zero.

RiskGeneral

Description	RiskGeneral (<i>minimum, maximum, {X1,X2,...,Xn}, {p1,p2,...,pn}</i>) generates a generalized probability distribution based on a density curve created using the specified (X,p) pairs. Each pair has a value X and a probability weight p which specifies the relative height of the probability curve at that X value. The weights p are normalized by @RISK in determining the actual probabilities used in sampling.
Examples	<p>RiskGeneral(0,10,{2,5,7,9},{1,2,3,1}) specifies a general probability distribution density function with four points. The distribution ranges from 0 to 10 with four points — 2,5,7,9 — specified on the curve. The height of the curve at 2 is 1, at 5 is 2, at 7 is 3 and at 9 is 1. The curve intersects the X-axis at 0 and 10.</p> <p>RiskGeneral(100,200,A1:C1,A2:C2) specifies a general probability distribution with three data points and a range of 100 to 200. The first row of the worksheet — A1 through C1 — holds the X value of each data point while row 2 — A2 through C2 — holds the p value at each of the three points in the distribution. Note that braces are not required when cell ranges are used as array entries to the function.</p>
Guidelines	<p>Probability weights p must be greater than or equal to zero. The sum of all weights must be greater than zero.</p> <p>X values must be entered in increasing order and must fall within the minimum-maximum range of the distribution.</p> <p><i>Minimum</i> value must be less than <i>maximum</i>.</p>

RiskGeomet

Description	RiskGeomet(<i>p</i>) generates a geometric distribution with the probability <i>p</i> . The value returned represents the number of failures prior to a success on a series of independent trials. There is a <i>p</i> probability of success on each trial. The geometric distribution is a discrete distribution returning only integer values greater than or equal to zero.
Examples	RiskGeomet(.25) specifies a geometric distribution with a 25% probability of success on each trial. RiskGeomet(A18) specifies a geometric distribution with a probability of success on each trial taken from cell A18.
Guidelines	Probability <i>p</i> must be greater than zero and less than or equal to one.

RiskHistogram

Description	RiskHistogram (<i>minimum</i> , <i>maximum</i> ,{ <i>p</i> 1, <i>p</i> 2,..., <i>p</i> <i>n</i> }) specifies a user-defined histogram distribution with a range defined by the specified <i>minimum</i> and <i>maximum</i> values. This range is divided into <i>n</i> classes. Each class has a weight <i>p</i> reflecting the probability of occurrence of a value within the class. These weights may be any values — the only important factor is the weight of one class relative to the others. This means that the sum of all the weights need not equal 100%. @RISK normalizes the class probabilities for you. Normalizing is done by summing all specified weights and dividing each weight by this sum.
Examples	RiskHistogram(10,20,{1,2,3,2,1}) specifies a histogram with a <i>minimum</i> value of 10 and a <i>maximum</i> value of 20. This range is divided into 5 equal length classes as there are 5 probability values. The probability weights for the five classes are the arguments 1, 2, 3, 2 and 1. The actual probabilities which would correspond with these weights are 11.1% (1/9), 22.2% (2/9), 33.3% (3/9), 22.2% (2/9) and 11.1% (1/9). Division by 9 normalizes these values so that their sum now equals 100%. RiskHistogram(A1,A2,B1:B3) specifies a histogram with a <i>minimum</i> value taken from cell A1 and a <i>maximum</i> value taken from cell A2. This range is divided into 3 equal length classes as there are 3 probability values. The probability weights are taken from cells B1 through B3.
Guidelines	Weight values <i>p</i> must be greater than or equal to zero, and the sum of all weights must be greater than zero.

RiskHypergeo

Description	RiskHypergeo (<i>n,D,M</i>) specifies a hypergeometric distribution with sample size <i>n</i> , number of items of a certain type equaling <i>D</i> and population size <i>M</i> . The hypergeometric distribution is a discrete distribution returning only non-negative integer values.
Examples	RiskHypergeo(50,10,1000) returns a hypergeometric distribution generated using a sample size of 50, 10 items of the relevant type and a population size of 1000. RiskHypergeo(A6,A7,A8) returns a hypergeometric distribution generated using a sample size taken from cell A6, a number of items taken from cell A7 and a population size taken from cell A8.
Guidelines	All arguments — <i>n</i> , <i>D</i> and <i>M</i> — must be positive integer values. The value for sample size <i>n</i> must be less than or equal to the population size <i>M</i> . The value for number of items <i>D</i> must be less than or equal to the population size <i>M</i> .

RiskIntUniform

Description	RiskIntUniform (<i>minimum,maximum</i>) specifies a uniform probability distribution with the entered <i>minimum</i> and <i>maximum</i> values. Only integer values across the range of the uniform distribution can occur and each has an equal likelihood of occurrence.
Examples	RiskIntUniform(10,20) specifies a uniform distribution with a <i>minimum</i> value of 10 and a <i>maximum</i> value of 20. RiskIntUniform(A1+90,B1) specifies a uniform distribution with a <i>minimum</i> value equaling the value in cell A1 plus 90 and a <i>maximum</i> value taken from cell B1.
Guidelines	The <i>minimum</i> value entered must be less than the <i>maximum</i> value.

RiskInvgauss

Description	<i>RiskInvgauss</i> (<i>mu</i> , <i>lambda</i>) specifies an inverse gaussian distribution with mean <i>mu</i> and shape parameter <i>lambda</i> .
Examples	RiskInvgauss(5,2) returns an inverse gaussian distribution with a <i>mu</i> value of 5 and a <i>lambda</i> value of 2. RiskInvgauss(B5,B6) returns an inverse gaussian distribution with a <i>mu</i> value taken from cell B5 and a <i>lambda</i> value taken from cell B6.
Guidelines	<i>mu</i> must be greater than zero. <i>lambda</i> must be greater than zero.

RiskInvgaussAlt

Description	<i>RiskInvgaussAlt</i> (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>) specifies an inverse gaussian distribution with three arguments of the type <i>arg1type</i> to <i>arg3type</i> . These arguments can be either a percentile between 0 and 1 or " <i>mu</i> ", " <i>lambda</i> " or " <i>loc</i> ".
Examples	RiskInvgaussAlt("mu",10,5%,1,95%,25) returns an inverse gaussian distribution with a <i>mu</i> value of 1, a 5 th percentile of 1 and a 95 th percentile of 25.
Guidelines	<i>mu</i> must be greater than zero. <i>lambda</i> must be greater than zero.

RiskLogistic

Description	<i>RiskLogistic</i> (<i>alpha</i> , <i>beta</i>) specifies a logistic distribution with the entered <i>alpha</i> and <i>beta</i> values.
Examples	RiskLogistic(10,20) returns a logistic distribution generated using an <i>alpha</i> value of 10 and a <i>beta</i> value of 20. RiskLogistic(A6,A7) returns a logistic distribution generated using an <i>alpha</i> value taken from cell A6 and a <i>beta</i> value taken from cell A7.
Guidelines	<i>Beta</i> must be a positive value.

RiskLogisticAlt

Description	RiskLogisticAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>) specifies a logistic distribution with two arguments of the type <i>arg1type</i> and <i>arg2type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>alpha</i> " or " <i>beta</i> ".
Examples	RiskLogisticAlt(5%,1,95%,100) returns a logistic distribution with a 5 th percentile of 1 and a 95 th percentile of 100.
Guidelines	" <i>Beta</i> " must be a positive value.

RiskLogLogistic

Description	RiskLoglogistic (<i>gamma</i> , <i>beta</i> , <i>alpha</i>) specifies a log-logistic distribution with location parameter <i>gamma</i> and shape parameter <i>alpha</i> and scale parameter <i>beta</i> .
Examples	RiskLoglogistic(-5,2,3) returns a log-logistic distribution generated using a <i>gamma</i> value of -5, a <i>beta</i> value of 2, and an <i>alpha</i> value of 3. RiskLoglogistic(A1,A2,A3) returns a log-logistic distribution generated using a <i>gamma</i> value taken from cell A1, a <i>beta</i> value taken from cell A2, and an <i>alpha</i> value taken from cell A3.
Guidelines	<i>Alpha</i> must be greater than zero. <i>Beta</i> must be greater than zero.

RiskLogLogisticAlt

Description	RiskLoglogisticAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>) specifies a log-logistic distribution distribution with three arguments of the type <i>arg1type</i> to <i>arg3type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>gamma</i> ", " <i>beta</i> " or " <i>alpha</i> ".
Examples	RiskLoglogisticAlt("gamma",5,"beta",2,90%,10) returns a log-logistic distribution generated using a <i>gamma</i> value of 5, a <i>beta</i> value of 2, and a 90 th percentile of 10.
Guidelines	" <i>Alpha</i> " must be greater than zero. " <i>Beta</i> " must be greater than zero

RiskLognorm

Description	RiskLognorm (<i>mean,standard deviation</i>) specifies a lognormal distribution with the entered <i>mean</i> and <i>standard deviation</i> . The arguments for this form of the lognormal distribution specify the actual <i>mean</i> and <i>standard deviation</i> of the generated lognormal probability distribution.
Examples	RiskLognorm(10,20) specifies a lognormal distribution with a <i>mean</i> of 10 and a <i>standard deviation</i> of 20. RiskLognorm(C10*3.14,B10) specifies a lognormal distribution with a <i>mean</i> equaling the value in cell C10 times 3.14 and a <i>standard deviation</i> equaling the value in cell B10.
Guidelines	The <i>mean</i> and <i>standard deviation</i> must be greater than 0.

RiskLognormAlt

Description	RiskLognormAlt (<i>arg1type, arg1value, arg2type,arg2value, arg3type,arg3value</i>) specifies a lognormal distribution distribution with three arguments of the type <i>arg1type</i> to <i>arg3type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>mu</i> ", " <i>sigma</i> " or " <i>loc</i> ".
Examples	RiskLognormAlt("mu",2,"sigma",5,95%,30) specifies a lognormal distribution with a <i>mean</i> of 2 and a <i>standard deviation</i> of 5 and a 95 th percentile of 30.
Guidelines	The " <i>mu</i> " and " <i>sigma</i> " must be greater than 0.

RiskLognorm2

Description	RiskLognorm2 (<i>mean of corresponding normal dist.,std. dev. of normal</i>) specifies a lognormal distribution where the entered mean and standard deviation equal the mean and standard deviation of the corresponding normal distribution. The arguments entered are the mean and standard deviation of the normal distribution for which an exponential of the values in the distribution was taken to generate the desired lognormal.
Examples	RiskLognorm2(10,20) specifies a lognormal distribution generated by taking the exponential of the values from a normal distribution with a <i>mean</i> of 10 and a <i>standard deviation</i> of 20. RiskLognorm2(C10*3.14,B10) specifies a lognormal distribution generated by taking the exponential of the values from a normal distribution with a <i>mean</i> equaling the value in cell C10 times 3.14 and a <i>standard deviation</i> equaling the value in cell B10.
Guidelines	The <i>standard deviation</i> must be greater than 0.

RiskNegbin

Description	RiskNegbin (<i>s,p</i>) specifies a negative binomial distribution with <i>s</i> number of successes and <i>p</i> probability of success on each trial. The negative binomial distribution is a discrete distribution returning only integer values greater than or equal to zero.
Examples	RiskNegbin(5,.25) specifies a negative binomial distribution with 5 successes with a 25% probability of success on each trial. RiskNegbin(A6,A7) specifies a negative binomial distribution with the number of successes taken from cell A6 and a probability of success taken from cell A7.
Guidelines	Number of successes <i>s</i> must be a positive integer less than or equal to 32,767. Probability <i>p</i> must be greater than zero and less than or equal to one.

RiskNormal

Description	RiskNormal (<i>mean,standard deviation</i>) specifies a normal distribution with the entered <i>mean</i> and <i>standard deviation</i> . This is the traditional "bell shaped" curve applicable to distributions of outcomes in many data sets.
Examples	RiskNormal(10,2) specifies a normal distribution with a <i>mean</i> of 10 and a <i>standard deviation</i> of 2. RiskNormal(SQRT(C101),B10) specifies a normal distribution with a <i>mean</i> equaling the square root of the value in cell C101 and a <i>standard deviation</i> taken from cell B10.
Guidelines	The <i>standard deviation</i> must be greater than 0.

RiskNormalAlt

Description	RiskNormalAlt (<i>arg1type, arg1value, arg2type,arg2value</i>) specifies a normal distribution with two arguments of the type <i>arg1type</i> and <i>arg2type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>mu</i> " or " <i>sigma</i> ".
Examples	RiskNormalAlt(5%,1,95%,10) specifies a normal distribution with a 5 th percentile of 1 and a 95 th percentile of 10.
Guidelines	" <i>sigma</i> " must be greater than 0.

RiskPareto

Description	RiskPareto (<i>theta,a</i>) specifies a pareto distribution with the entered <i>theta</i> and a values.
Examples	RiskPareto(5,5) specifies a pareto distribution with a <i>theta</i> value of 5 and an <i>a</i> value of 5. RiskPareto(A10,A11+A12) specifies a pareto distribution with a <i>theta</i> value taken from cell A10 and an <i>a</i> value given by the result of the expression A11+A12.
Guidelines	<i>Theta</i> must be greater than 1. The <i>a</i> argument must be greater than 0.

RiskParetoAlt

Description	RiskParetoAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>) specifies a pareto distribution with two arguments of the type <i>arg1type</i> and <i>arg2type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>theta</i> " or " <i>alpha</i> ".
Examples	RiskParetoAlt(5%,1,95%,4) specifies a pareto distribution with a 5 th percentile of 1 and a 95 th percentile of 4.
Guidelines	" <i>Theta</i> " must be greater than 1. " <i>alpha</i> " must be greater than 0.

RiskPareto2

Description	RiskPareto2 (<i>b</i> , <i>q</i>) specifies a pareto distribution with the entered <i>b</i> and <i>q</i> values.
Examples	RiskPareto2(5,5) specifies a pareto distribution with a <i>b</i> value of 5 and a <i>q</i> value of 5. RiskPareto2(A10,A11+A12) specifies a pareto distribution with a <i>b</i> value taken from cell A10 and a <i>q</i> value given by the result of the expression A11+A12.
Guidelines	<i>b</i> must be greater than 0. <i>q</i> must be greater than 0.

RiskPareto2Alt

Description	RiskPareto2Alt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>) specifies a pareto distribution with two arguments of the type <i>arg1type</i> and <i>arg2type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>b</i> " or " <i>q</i> ".
Examples	RiskPareto2Alt(5%,.05,95%,5) specifies a pareto distribution with a 5 th percentile of .05 and a 95 th percentile of 5.
Guidelines	" <i>b</i> " must be greater than 0. " <i>q</i> " must be greater than 0.

RiskPearson5

Description	RiskPearson5 (<i>alpha</i> , <i>beta</i>) specifies a pearson type V distribution with shape parameter <i>alpha</i> and scale parameter <i>beta</i> .
Examples	RiskPearson5(1,1) specifies a pearson type V distribution where the shape parameter has a value of 1 and the scale parameter has a value of 1. RiskPearson5(C12,C13) specifies a pearson type V distribution where the shape parameter has a value taken from cell C12 and the scale parameter has a value taken from cell C13.
Guidelines	<i>Alpha</i> must be greater than zero <i>Beta</i> must be greater than zero.

RiskPearson5Alt

Description	RiskPearson5Alt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>) specifies a pearson type V distribution with three arguments of the type <i>arg1type</i> to <i>arg3type</i> . These arguments can be either a percentile between 0 and 1 or " <i>alpha</i> ", " <i>beta</i> " or " <i>loc</i> ".
Examples	RiskPearson5Alt("alpha",2,"beta",5,95%,30) specifies a pearson type V distribution with a <i>alpha</i> of 2 and a <i>beta</i> of 5 and a 95 th percentile of 30.
Guidelines	" <i>Alpha</i> " must be greater than zero " <i>Beta</i> " must be greater than zero.

RiskPearson6

Description	RiskPearson6 (<i>alpha1</i> , <i>alpha2</i> , <i>beta</i>) specifies a pearson type VI distribution with scale parameter <i>beta</i> and shape parameters <i>alpha1</i> and <i>alpha2</i> .
Examples	RiskPearson6(5,1,2) specifies a pearson type VI distribution where <i>beta</i> has a value of 2, <i>alpha2</i> has a value of 1 and <i>alpha1</i> has a value of 5. RiskPearson6(E3,F3,D3) specifies a pearson type VI distribution where <i>beta</i> has a value taken from cell D3, <i>alpha1</i> has a value taken from cell E3, and <i>alpha2</i> has a value taken from cell F3.
Guidelines	<i>Alpha1</i> must be greater than zero. <i>Alpha2</i> must be greater than zero. <i>Beta</i> must be greater than zero.

RiskPert

Description	RiskPert (<i>minimum, most likely, maximum</i>) specifies a PERT distribution (as special form of the beta distribution) with a <i>minimum</i> and <i>maximum</i> value as specified. The shape parameter is calculated from the defined <i>most likely</i> value.
Examples	RiskPert(0,2,10) specifies a beta distribution with a minimum of 0, a maximum of 10, and a most likely value of 2. RiskPert (A1,A2,A3) specifies a PERT distribution with a minimum value taken from cell A1, a maximum value taken from cell A3, and a most likely value taken from cell A2.
Guidelines	<i>Minimum</i> must be less than <i>maximum</i> . <i>Most likely</i> must be greater than <i>minimum</i> and less than <i>maximum</i> .

RiskPertAlt

Description	RiskPertAlt (<i>arg1type, arg1value, arg2type,arg2value, arg3type,arg3value</i>) specifies a PERT distribution with three arguments of the type <i>arg1type</i> to <i>arg3type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>min</i> ", " <i>m. likely</i> " or " <i>max</i> ".
Examples	RiskPertAlt("min",2,"m. likely",5,95%,30) specifies a PERT distribution with a <i>minimum</i> of 2 and a most likely value of 5 and a 95 th percentile of 30.
Guidelines	" <i>min</i> " must be less than or equal to the " <i>m. likely</i> " value. " <i>m. likely</i> " must be less than or equal to the " <i>max</i> " value. The " <i>min</i> " must be less than the " <i>max</i> " value.

RiskPoisson

Description	RiskPoisson (<i>lambda</i>) specifies a poisson distribution with the specified <i>lambda</i> value. The argument <i>lambda</i> is also the same as the mean of the poisson distribution. The poisson distribution is a discrete distribution returning only integer values greater than or equal to zero.
Examples	RiskPoisson(5) specifies a poisson distribution with a <i>lambda</i> of 5. RiskPoisson(A6) specifies a poisson distribution with a <i>lambda</i> value taken from cell A6.
Guidelines	<i>Lambda</i> must be greater than zero.

RiskRayleigh

Description	RiskRayleigh (<i>b</i>) specifies a rayleigh distribution with mode <i>b</i> .
Examples	RiskRayleigh(3) specifies a rayleigh distribution with a mode of 3. RiskRayleigh(C7) specifies a rayleigh distribution with a mode taken from the value in cell C7.
Guidelines	<i>b</i> must be greater than zero.

RiskRayleighAlt

Description	RiskRayleighAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>) specifies a rayleigh distribution with two arguments of the type <i>arg1type</i> and <i>arg2type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>beta</i> " or " <i>loc</i> ".
Examples	RiskRayleighAlt(5%,1,95%,10) specifies a normal distribution with a 5 th percentile of 1 and a 95 th percentile of 10.
Guidelines	" <i>beta</i> " must be greater than zero.

RiskSimtable

Description	RiskSimtable (<i>{val1,val2,...,valn}</i>) specifies a list of values which will be used sequentially in individual simulations executed during a Sensitivity Simulation. In a Sensitivity Simulation the number of simulations, set using the Iterations Simulations command, is greater than one. In a single simulation or a normal recalculation RiskSimtable returns the first value in the list. Any number of RiskSimtable functions may be included in a single worksheet. As with other functions, the arguments of RiskSimtable may include distribution functions.
Examples	RiskSimtable({10,20,30,40}) specifies four values to be used in each of four simulations. In Simulation #1 the SIMTABLE function will return 10, Simulation #2 the value 20 and so on. RiskSimtable(A1:A3) specifies a list of three values for three simulations. In Simulation #1 the value from cell A1 will be returned. In Simulation #2 the value from cell A2 will be returned. In Simulation #3 the value from cell A3 will be returned.
Guidelines	Any number of arguments may be entered. The number of simulations executed must be less than or equal to the number of arguments. If the number of arguments is less than the number of an executing simulation, ERR will be returned by the function for that simulation.

RiskStudent

Description	RiskStudent (<i>nu</i>) specifies a student's t distribution with <i>nu</i> degrees of freedom.
Examples	RiskStudent(10) specifies a student's t distribution with 10 degrees of freedom. RiskStudent(J2) specifies a student's t distribution with the degrees of freedom taken from the value in cell J2.
Guidelines	<i>Nu</i> must be a positive integer.

RiskTriang

Description	RiskTriang (<i>minimum,most likely,maximum</i>) specifies a triangular distribution with three points — a <i>minimum</i> , <i>most likely</i> and <i>maximum</i> . The direction of the "skew" of the triangular distribution is set by the size of the <i>most likely</i> value relative to the <i>minimum</i> and the <i>maximum</i> .
Examples	RiskTriang(100,200,300) specifies a triangular distribution with a <i>minimum</i> value of 100, a <i>most likely</i> value of 200 and a <i>maximum</i> value of 300. RiskTriang(A10/90,B10,500) specifies a triangular distribution with a <i>minimum</i> value equaling the value in cell A10 divided by 90, a <i>most likely</i> value taken from cell B10 and a <i>maximum</i> value of 500.
Guidelines	The <i>minimum</i> value must be less than or equal to the <i>most likely</i> value. The <i>most likely</i> value must be less than or equal to the <i>maximum</i> value. The <i>minimum</i> value must be less than the <i>maximum</i> value.

RiskTriangAlt

Description	RiskTriangAlt (<i>arg1type, arg1value, arg2type,arg2value, arg3type,arg3value</i>) specifies a triangular distribution with three arguments of the type <i>arg1type</i> to <i>arg3type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>min</i> ", " <i>m. likely</i> " or " <i>max</i> ".
Examples	RiskTriangAlt("min",2,"m. likely",5,95%,30) specifies a triangular distribution with a <i>minimum</i> of 2 and a most likely value of 5 and a 95 th percentile of 30.
Guidelines	" <i>min</i> " must be less than or equal to the " <i>m. likely</i> " value. " <i>m. likely</i> " must be less than or equal to the " <i>max</i> " value. The " <i>min</i> " must be less than the " <i>max</i> " value.

RiskTrigen

Description	RiskTrigen (<i>bottom value,most likely value,top value, bottom perc., top perc.</i>) specifies a triangular distribution with three points — one at the most likely value and two at the specified bottom and top percentiles. The bottom percentile and top percentile are values between 0 and 100. Each percentile value gives the percentage of the total area under the triangle that falls to the left of the entered point. Use of the RiskTrigen function avoids the problem of the minimum and maximum values not actually being possible occurrences in the standard RiskTriang function. This is because in the RiskTriang function these are the points where the distribution intersects the X-axis, or points of zero probability.
Examples	RiskTrigen(100,200,300,10,90) specifies a triangular distribution with a <i>10th percentile value</i> of 100, a <i>most likely value</i> of 200 and a <i>90th percentile value</i> of 300. RiskTrigen(A10/90,B10,500,30,70) specifies a triangular distribution with a <i>30th percentile value</i> equaling the value in cell A10 divided by 90, a <i>most likely value</i> taken from cell B10 and a <i>70th percentile value</i> of 500.
Guidelines	The <i>bottom percentile value</i> must be less than or equal to the <i>most likely value</i> . The <i>most likely value</i> must be less than or equal to the <i>top percentile value</i> . The <i>bottom percentile value</i> must be less than the <i>top percentile value</i> .

RiskUniform

Description	RiskUniform (<i>minimum,maximum</i>) specifies a uniform probability distribution with the entered <i>minimum</i> and <i>maximum</i> values. Every value across the range of the uniform distribution has an equal likelihood of occurrence.
Examples	RiskUniform(10,20) specifies a uniform distribution with a <i>minimum</i> value of 10 and a <i>maximum</i> value of 20. RiskUniform(A1+90,B1) specifies a uniform distribution with a <i>minimum</i> value equaling the value in cell A1 plus 90 and a <i>maximum</i> value taken from cell B1.
Guidelines	The <i>minimum</i> value entered must be less than the <i>maximum</i> value.

RiskUniformAlt

Description	RiskUniformAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i>) specifies a uniform distribution with two arguments of the type <i>arg1type</i> and <i>arg2type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>min</i> " or " <i>max</i> ".
Examples	RiskUniformAlt (5%,1,95%,10) specifies a uniform distribution with a 5 th percentile of 1 and a 95 th percentile of 10.
Guidelines	The " <i>min</i> " value entered must be less than the " <i>max</i> " value.

RiskWeibull

Description	RiskWeibull (<i>alpha</i> , <i>beta</i>) generates a weibull distribution with the shape parameter <i>alpha</i> and a scale parameter <i>beta</i> . The weibull distribution is a continuous distribution whose shape and scale vary greatly depending on the argument values entered.
Examples	RiskWeibull (10,20) generates a weibull distribution with a shape parameter 10 and a scale parameter 20. RiskWeibull (D1,D2) generates a weibull distribution with a shape parameter taken from cell D1 and a scale parameter taken from cell D2.
Guidelines	Both shape parameter <i>alpha</i> and scale parameter <i>beta</i> must be greater than zero.

RiskWeibullAlt

Description	RiskWeibullAlt (<i>arg1type</i> , <i>arg1value</i> , <i>arg2type</i> , <i>arg2value</i> , <i>arg3type</i> , <i>arg3value</i>) specifies a weibull distribution with three arguments of the type <i>arg1type</i> to <i>arg3type</i> . These arguments can be either a <i>percentile</i> between 0 and 1 or " <i>alpha</i> ", " <i>beta</i> " or " <i>loc</i> ".
Examples	RiskWeibullAlt ("alpha",1,"beta",1,95%,3) specifies a weibull distribution with a <i>alpha</i> of 1 and a <i>beta</i> of 1 and a 95 th percentile of 3.
Guidelines	Both shape parameter " <i>alpha</i> " and scale parameter " <i>beta</i> " must be greater than zero.

Reference: Distribution Property Functions

The following functions are used to add optional arguments to distribution functions. The arguments added by these functions are not required, but can be added as needed.

Optional arguments are specified using @RISK distribution property functions that are embedded inside of a distribution function.

RiskCollect

Description	<p>RiskCollect() identifies specific distribution functions whose samples are collected during a simulation and whose:</p> <ul style="list-style-type: none">statistics are displayeddata points are availablesensitivities and scenario values are calculated <p>When RiskCollect is used and Inputs Marked With Collect is selected for Collect Distribution Samples in the Simulation Settings dialog, only functions identified by RiskCollect are displayed in the Results window Explorer list.</p> <p>Earlier versions of @RISK had the RiskCollect function entered by placing it in the cell formula immediately preceding the distribution function for which samples will be collected, e.g.:</p> <p>=RiskCollect()+RiskNormal(10,10)</p> <p>RiskCollect is typically used when a large number of distribution functions are present in a simulated worksheet, but sensitivities and scenario analyses are desired on only a pre-identified subset of important distributions. It can also be used to bypass Windows memory constraints that keep sensitivities and scenario analyses from being performed on all functions in a large simulation.</p>
Examples	<p>RiskNormal(10,2,RiskCollect()) collects samples from the probability distribution RiskNormal(10,2).</p>
Guidelines	<p>The "Inputs Marked WithCollect" box in Simulation Settings must be selected for COLLECT functions to take effect.</p>

RiskCorrmat

<p>Description</p>	<p>RiskCorrmat(<i>matrix cell range,position,instance</i>) identifies a distribution function belonging to a set of correlated distribution functions. The function is used to specify multivariate correlation. RiskCorrmat identifies 1) a matrix of rank correlation coefficients and 2) the location in the matrix of the coefficients used in correlating the distribution function which follows the RiskCorrmat function.</p> <p>Correlated distribution functions typically are defined using the @RISK Model Window Model menu Correlate Distributions command; however, the same type of correlation may be directly entered in your spreadsheet using the RiskCorrmat function.</p> <p>The matrix identified by the <i>matrix cell range</i> is a matrix of rank correlation coefficients. Each element (or cell) in the matrix contains a correlation coefficient. The number of distribution functions correlated by the matrix equals the number of rows or columns in the matrix. The argument <i>position</i> specifies the column (or row) in the matrix to use in correlating the distribution function which follows the RiskCorrmat function. The coefficients located in the column (or row) identified by <i>position</i> are used in correlating the identified distribution function with each of the other correlated distribution functions represented by the matrix. The value in any given cell in the matrix gives the correlation coefficient between 1) the distribution function whose RiskCorrmat <i>position</i> equals the column coordinate of the cell and 2) the distribution function whose RiskCorrmat <i>position</i> equals the row coordinate of the cell. <i>Positions</i> (and coordinates) range from 1 to N, where N is the number of columns or rows in the matrix.</p> <p>The <i>instance</i> argument is optional and is used when multiple groups of correlated inputs use the same matrix of correlation coefficients. <i>Instance</i> is an integer or string argument and all inputs in a correlated group of inputs share the same instance value or string. String arguments used to specify <i>instance</i> need to be in quotes.</p> <p>The RiskCorrmat function generates correlated sets of random numbers to be used in sampling each of the correlated distribution functions. The sample matrix of rank correlation coefficients calculated on the correlated set of random numbers approximates as closely as possible the target correlation coefficient matrix which was entered in the worksheet.</p> <p>Correlated sets of random numbers specified by the RiskCorrmat function are generated when the first RiskCorrmat function is called during a simulation. This is usually during the first iteration of the simulation. This may cause a delay while values are sorted and correlated. The length of the delay is proportional to the number of iterations and the number of correlated variables.</p> <p>The method used for generating multiple rank correlated distribution functions is based on the method used for DEPC and INDEPC functions. For more information on this, see the section Understanding Rank Order Correlation Coefficient Values under the DEPC function in this section.</p> <p>Entry of CORRMAT functions outside of a distribution function (in the form <i>RiskCorrmat+distribution function</i>) as done in earlier versions of @RISK is still supported. However, these functions will be moved inside the distribution function they are correlating whenever the formula or correlated distribution is edited in the @RISK Model window.</p>
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Examples	<p>RiskNormal(10,10, RiskCorrmat(C10:G14,1,"Matrix 1")) specifies that the sampling of the distribution Normal(10,10) will be controlled by the first column of the 5 by 5 matrix of correlation coefficient values located in the cell range C10:G14. There are five correlated distributions represented by the matrix as there are five columns in the matrix. The coefficients used in correlating Normal(10,10) with the other four correlated distributions are found in row 1 of the matrix. This distribution - Normal(10,10) - will be correlated with the other distributions that include the instance <i>Matrix 1</i> in their embedded RiskCorrmat functions.</p>
Guidelines	<p>Multiple matrices of correlation coefficients may be used in a single worksheet. The sample matrix of correlation coefficients (calculated on the correlated random numbers generated by @RISK) approximates as closely as possible the target correlation coefficient matrix located in the <i>matrix cell range</i>. It is possible that the target coefficients are inconsistent and approximation cannot be performed. @RISK will notify the user if this occurs.</p> <p>Any blank cells or labels in the <i>matrix cell range</i> specify a correlation coefficient of zero.</p> <p><i>Position</i> may be a value between 1 and N, where N is the number of columns in the matrix.</p> <p>The <i>matrix cell range</i> must be square, that is, with an equal number of rows and columns.</p> <p>By default @RISK uses the correlation coefficients in the <i>matrix cell range</i> on a rowwise basis. Because of this only the top 'half' of the matrix — the top right of the matrix when it is split on the diagonal — needs to be entered.</p> <p>Correlation coefficients must be less than or equal to 1 and greater than or equal to -1. Coefficients on the diagonal of the matrix must equal 1.</p>

RiskDepC

Description	<p>RiskDepC("ID",coefficient) designates a dependent variable in a correlated sampling pair. The <i>ID</i> in quotes is the string used to identify the independent variable being correlated with. The string must be in quotes. This is the same <i>ID</i> used in the RiskIndepC function for the independent variable. The coefficient entered is the rank-order correlation coefficient which describes the relationship of the values sampled for the distributions identified by the RiskDepC and RiskIndepC. The RiskDepC function is used with the distribution function which specifies the possible values for the dependent variable</p> <p><u>Understanding Rank-Order Correlation Coefficient Values</u></p> <p>The rank-order correlation coefficient was developed by C. Spearman in the early 1900's. It is calculated using rankings of values, not actual values themselves (as is the linear correlation coefficient). A value's "rank" is determined by its position within the min-max range of possible values for the variable.</p> <p>The coefficient is a value between -1 and 1 which represents the desired degree of correlation between the two variables during sampling. Positive coefficient values indicate a positive relationship between the two variables — when the value sampled for one is high, the value sampled for the second will also tend to be high. Negative coefficient values indicate an inverse relationship between the two variables — when the value sampled for one is high, the value sampled for the second will tend to be low.</p> <p>@RISK generates rank-correlated pairs of sampled values in a two step process. First, a set of randomly distributed "rank scores" are generated for each variable. If 100 iterations are to be run, for example, 100 scores are generated for each variable. (Rank scores are simply values of varying magnitude between a minimum and maximum. @RISK uses van der Waerden scores based on the inverse function of the normal distribution). These rank scores are then rearranged to give pairs of scores which generate the desired rank correlation coefficient. For each iteration there is a pair of scores, with one score for each variable.</p> <p>In the second step, a set of random numbers (between 0 and 1) to be used in sampling is generated for each variable. Again, if 100 iterations are to be run, 100 random numbers are generated for each variable. These random numbers are then ranked smallest to largest. For each variable, the smallest random number is then used in the iteration with the smallest rank score, the second smallest random number is used in the iteration with the second smallest rank score and so on. This ordering based on ranking continues for all random numbers, up to the point where the largest random number is used in the iteration with the largest rank score.</p> <p>In @RISK this process of rearranging random numbers happens prior to simulation. It results in a set of pairs of random numbers that can be used in sampling values from the correlated distributions in each iteration of the simulation.</p> <p>This method of correlation is known as a "distribution-free" approach because any types of distributions may be correlated. Although the samples drawn for the two distributions are correlated, the integrity of the original distributions are maintained. The resulting samples for each distribution reflect the input distribution function from which they were drawn.</p>
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	<p>Earlier versions of @RISK had the RiskDepC function entered by placing it in the cell formula immediately preceding the distribution function which will be correlated, e.g.:</p> <p>=RiskDepC("Price 1",.9)+RiskNormal(10,10)</p> <p>This form of function entry is still supported. However, these functions will be moved inside the distribution function they are correlating whenever the formula or correlated distribution is edited in the @RISK Model window.</p> <p>The correlation coefficient generated by using RiskDepC and RiskIndepC is approximate. The generated coefficient will more closely approximate the desired coefficient as increasing numbers of iterations are executed. There may be a delay at the start of a simulation when distributions are correlated when RiskDepC and RiskIndepC are used. The length of the delay is proportional to the number of RiskDepC functions in the worksheet and the number of iterations to be performed. See the @RISK Modeling Techniques chapter for a detailed example of dependency relationships</p>
Examples	<p>RiskNormal(100,10, RiskDepC("Price",.5)) specifies that the sampling of the distribution RiskNormal(100,10) will be correlated with the sampling of the distribution identified with the function RiskIndepC("Price"). The sampling of RiskNormal(100,10) will be positively correlated with the sampling of the distribution identified with the function RiskIndepC("Price") as the <i>coefficient</i> is greater than 0.</p>
Guidelines	<p><i>Coefficient</i> must be a value greater than or equal to -1 and less than or equal to 1. <i>ID</i> must be the same string of characters used to identify the independent variable in the RiskIndepC function. <i>ID</i> may be a reference to cell that contains an identifier string.</p>

RiskFit

Description	<p><i>RiskFit(ProjID,FitID,"selected fit result")</i> links a data set and its fit results to the input distribution the RiskFit function is used in. The <i>ProjID</i> and <i>FitID</i> are internal @RISK IDs that identify the fit from which the distribution was selected and should not be changed. The <i>selected fit result</i> in quotes is a string used to identify the type of fit result to select. The RiskFit function is used to link an input to the fit results for a data set so that when the data is changed the input distribution selected from the fit can be updated.</p> <p>The <i>selected fit result</i> can be any of the following entries:</p> <p>Best Chi-Sq, indicating the best fitting distribution from the Chi-Sq. test should be used</p> <p>Best A-D, indicating the best fitting distribution from the Anderson-Darling test should be used</p> <p>Best K-S, indicating the best fitting distribution from the Kolmogorov-Smirnov test should be used.</p> <p>Best RMS Err, indicating the best fitting distribution from the RMS Error test should be used</p> <p>A distribution name, such as "<i>Normal</i>", indicating that the best-fitting distribution of the entered type should be used.</p> <p>What Happens When Data Changes When RiskFit is Used</p> <p>The RiskFit function "hot-links" a distribution function to a data set and the fit of that data set. The data used in a fit can be either in Excel or on a fit tab in the @RISK – Model window. When the fitted data changes in either one of these locations, the following actions take place:</p> <p>@RISK re-runs the fit using the current settings on the fit tab where the fit was originally run</p> <p>The distribution function that includes the RiskFit function that references the fit is changed to reflect the new fit results. The changed function replaces the original one in Excel. If, for example, the distribution function's RiskFit argument specified "Best Chi-sq" for <i>selected fit result</i>, the new best-fitting distribution based on the Chi-Sq test would replace the original one. This new function would also include the same RiskFit function as the original one.</p> <p>@RISK can perform the above actions either 1) immediately when the data and fit have changed or 2) when a simulation starts or the list of Outputs and Inputs is generated. The Update method used is specified using the @RISK Model window Fitting menu Update Linked @RISK Functions command.</p>
Examples	<p>RiskNormal(2.5, 1, RiskFit(71367, 59129, "Best A-D")) specifies that the best fitting distribution from the Anderson-Darling test for the fitted data associated with the specified <i>ProjID</i> and <i>FitID</i> is a Normal distribution with a mean of 2.5 and a standard deviation of 1.</p>
Guidelines	<p>n/a</p>

RiskIndepC

Description	<p>RiskIndepC("ID") designates an independent variable in a rank correlated sampling pair. The <i>ID</i> in quotes is a string used to identify the independent variable. The RiskIndepC function is used with the distribution function which specifies the possible values for the independent variable. RiskIndepC is just an identifier.</p> <p>Earlier versions of @RISK had the RiskIndepC function entered by placing it in the cell formula immediately preceding the distribution function which will be correlated, e.g.:</p> <p>=RiskIndepC("Price 1")+RiskNormal(10,10)</p> <p>This form of function entry is still supported. However, these functions will be moved inside the distribution function they are correlating whenever the formula or correlated distribution is edited in the @RISK Model window.</p>
Examples	<p>RiskNormal(10,10, RiskIndepC("Price")) identifies the function NORMAL(10,10) as the independent variable "Price". This function will be used as the independent variable anytime a DEPC function with the ID string "Price" is used.</p>
Guidelines	<p>"ID" must be the same string of characters used to identify the dependent variable in the DEPC function. "ID" must be the same string of characters used to identify the independent variable in the INDEPC function. "ID" may be a reference to cell that contains an identifier string.</p> <p>A maximum of 64 individual INDEPC functions may be used in a single worksheet. Any number of DEPC functions may be dependent on those INDEPC functions</p> <p>See the @RISK Modeling Techniques chapter for a detailed example of dependency relationships.</p>

RiskLock

Description	<i>RiskLock()</i> keeps a distribution from being sampled in a simulation. Locking an input distribution causes it to return the value set in using the Simulation Settings standard recalc options.
Examples	RiskNormal(10,2,RiskLock()) stops samples from being drawn from the probability distribution RiskNormal(10,2).
Guidelines	None

RiskName

Description	<i>RiskName("Input Name")</i> names the input distribution in which the function is used as an argument. This name will appear in both the @RISK Model Window Outputs and Inputs list and in any reports and graphs which include simulation results for the input.
Examples	RiskTriang(10,20,30,RiskName("Price")) gives the name Price to the input described by the probability distribution RiskTriang(10,20,30). RiskTriang(10,20,30,RiskName(A10)) gives the name contained in the cell A10 to the input described by the probability distribution RiskTriang(10,20,30).
Guidelines	The name specified must be entered in quotes. Any valid cell references can be used to define a name.

RiskShift

Description	<i>RiskShift(shift amount)</i> shifts the domain of the distribution in which it is used by the entered <i>shift amount</i> . This function is automatically entered when a fit result includes a shift factor.
Examples	RiskBeta(10,2,RiskShift(100)) shifts the domain of the distribution RiskBeta(10,2) by 100 .
Guidelines	None.

RiskTruncate

Description	<i>RiskTruncate</i> (<i>minimum,maximum</i>) truncates the input distribution in which the function is used as an argument. Truncating a distribution restricts samples drawn from the distribution to values within the entered <i>minimum-maximum</i> range. Truncated forms of specific distributions available in earlier versions of @RISK (such as RiskTnormal and RiskTlognorm) are still supported.
Examples	RiskTriang(10,20,30,RiskTruncate(13,27)) restricts the samples drawn from the probability distribution RiskTriang(10,20,30) to a minimum possible value of 13 and a maximum possible value of 27. RiskTriang(10,20,30,RiskTruncate(D11,D12)) restricts the samples drawn from the probability distribution RiskTriang(10,20,30) to a minimum possible value of taken from cell D11 and a maximum possible value of taken from cell D12.
Guidelines	Minimum <i>must be less than or equal to</i> maximum.

Reference: Output Functions

Output cells are defined using RiskOutput functions. These functions allow the easy copying, pasting and moving of output cells. RiskOutput functions are automatically added when the standard @RISK Add Output icon is pressed. RiskOutput functions optionally allow you to name your simulation outputs and add individual output cells to output ranges.

RiskOutput

Description	<p>The function RiskOutput is used to identify output cells you have selected in your spreadsheet. This function takes up to three arguments as shown here: =RiskOutput("output cell name", "output range name",element# in range)</p> <p>These arguments are optional, as a simple =RiskOutput() is sufficient for entering a single element output range where @RISK creates the name of the output for you. RiskOutput used with a single argument such as: =RiskOutput ("output cell name")</p> <p>specifies for a single element output range where the name is entered by you. When a multiple element output range is identified, the form: =RiskOutput ("output cell name", "output range name", position# in range)</p> <p>is used; however, the output cell name entry can be omitted if you wish to have @RISK automatically generate a name for each output cell in the range. RiskOutput functions are automatically generated for you when you select outputs using the @RISK Add Output icon. However, like any other @RISK function, RiskOutput may be typed directly in the cell which you wish to reference as a simulation output.</p> <p>A RiskOutput function is entered by adding it to the cell formula which is already present in the cell that is to be a simulation output. For example, a cell containing the formula: =NPV(.1,G1...G10)</p> <p>would become =RiskOutput()+NPV(.1,G1...G10)</p> <p>when the cell is selected as an output.</p>
Examples	<p>=RiskOutput("Profit 1999", "Annual Profit", 1)+NPV(.1,G1...G10) identifies the cell where the RiskOutput function is located as a simulation output and gives it the name <i>Profit 1999</i> and makes it the first cell in a multiple cell output range named <i>Annual Profit</i>.</p>
Guidelines	<p>If names are entered directly in the RiskOutput function, the entered output cell name and output range name must be enclosed in quotes. Names may also be included by referencing cells with labels in them.</p> <p>Position# must be a positive integer >=1.</p>

Reference: Statistics Functions

Statistics Functions return a desired statistic on simulation results for 1) a specified cell or 2) a simulation output or input. These functions are updated real-time as a simulation is running. Statistics functions located in template sheets used for creating custom reports on simulation results are only updated when a simulation is completed.

If a cell reference is entered as the first argument, the cell does not have to be a simulation output identified with a RiskOutput function.

If a name is entered instead of cellref, @RISK first checks for an output with the entered name. If none exists, @RISK looks for an input probability distribution with the entered name and if one is found, returns the appropriate statistic for the samples drawn for that input. It is up to the user to insure that unique names are given to outputs and inputs referenced in statistics functions.

The Sim# argument entered selects the simulation for which a statistic will be returned when multiple simulations are run. This argument is optional and can be omitted for single simulation runs.

RiskData

Description	RiskData (cellref or output/input name,iteration#,Sim#) returns the data point(s) of the simulated distribution for cellref in the specified iteration# and simulation#. RiskData can optionally be entered as an array formula, where iteration# is the first iteration to be returned in the first cell in the array formula range. The data points for each subsequent iteration will be filled into cells in the range where the array formula is entered.
Examples	RiskData(A10,1) returns the data point of the simulated distribution for cell A10 in iteration #1 of a simulation. RiskData("Profit",100,2) returns the data point of the simulated distribution for the output cell named Profit in the current model for the 100 th iteration of the second simulation executed when multiple simulations are run.
Guidelines	None.

RiskKurtosis

Description	<i>RiskKurtosis</i> (<i>cellref</i> or <i>output/input name</i> , <i>Sim#</i>) returns the kurtosis of the simulated distribution for <i>cellref</i> .
Examples	RiskKurtosis(A10) returns the kurtosis of the simulated distribution for cell A10. RiskKurtosis("Profit",2) returns the kurtosis of the simulated distribution for the output cell named Profit in the current model for the second simulation executed when multiple simulations are run.
Guidelines	None.

RiskMax

Description	<i>RiskMax</i> (<i>cellref</i> or <i>output/input name</i> , <i>Sim#</i>) returns the maximum value of the simulated distribution for <i>cellref</i> .
Examples	RiskMax(A10) returns the maximum of the simulated distribution for cell A10. RiskMax("profit") returns the maximum of the simulated distribution for the output cell in the current model named "profit".
Guidelines	None.

RiskMean

Description	<i>RiskMean</i> (<i>cellref</i> or <i>output/input name</i> , <i>Sim#</i>) returns the mean value of the simulated distribution for <i>cellref</i> .
Examples	RiskMean(A10) returns the mean of the simulated distribution for cell A10 RiskMean("Price") returns the mean of the simulated distribution for the output cell named Price.
Guidelines	None.

RiskMin

Description	<i>RiskMin</i> (<i>cellref or output/input name, Sim#</i>) returns the minimum value of the simulated distribution for <i>cellref</i> .
Examples	RiskMin(A10) returns the minimum of the simulated distribution for cell A10. RiskMin("Sales") returns the minimum value of the simulated distribution for the output cell in the current model named "Sales".
Guidelines	None.

RiskMode

Description	<i>RiskMode</i> (<i>cellref or output/input name, Sim#</i>) returns the mode of the simulated distribution for <i>cellref</i> .
Examples	RiskMode(A10) returns the mode of the simulated distribution for cell A10. RiskMode("Sales") returns the mode of the simulated distribution for the output cell in the current model named "Sales".
Guidelines	None.

RiskPercentile

Description	<i>RiskPercentile</i> (<i>cellref or output/input name, percentile, Sim#</i>) returns the value of the entered <i>percentile</i> of the simulated distribution for <i>cellref</i> .
Examples	RiskPercentile(C10,,99) returns the 99 th percentile of the simulated distribution for cell C10. RiskPercentile(C10,A10) returns the percentile value from cell A10 of the simulated distribution for cell C10.
Guidelines	The entered percentile must be a value ≥ 0 and ≤ 1 .

RiskRange

Description	<i>RiskRange</i> (<i>cellref</i> or <i>output/input name</i> , <i>Sim#</i>) returns the minimum-maximum range of the simulated distribution for <i>cellref</i> .
Examples	RiskRange(A10) returns the range of the simulated distribution for cell A10.
Guidelines	None.

RiskSkewness

Description	<i>RiskSkewness</i> (<i>cellref</i> or <i>output/input name</i> , <i>Sim#</i>) returns the skewness of the simulated distribution for <i>cellref</i> .
Examples	RiskSkewness(A10) returns the skewness of the simulated distribution for cell A10.
Guidelines	None.

RiskStdDev

Description	<i>RiskSkewness</i> (<i>cellref</i> or <i>output/input name</i> , <i>Sim#</i>) returns the skewness of the simulated distribution for <i>cellref</i> .
Examples	RiskSkewness(A10) returns the skewness of the simulated distribution for cell A10.
Guidelines	None.

RiskStdDev

Description	<i>RiskStdDev</i> (<i>cellref</i> or <i>output/input name</i> , <i>Sim#</i>) returns the standard deviation of the simulated distribution for <i>cellref</i> .
Examples	RiskStdDev(A10) returns the standard deviation of the simulated distribution for cell A10.
Guidelines	None.

RiskTarget

Description	RiskTarget (<i>cellref</i> or <i>output/input name</i> , <i>targetvalue</i> , <i>Sim#</i>) returns the cumulative probability for <i>targetvalue</i> in the simulated distribution for <i>cellref</i> . The cumulative probability returned is the probability of a value <= <i>targetvalue</i> occurring.
Examples	RiskTarget(C10,100000) returns the cumulative probability of the value 100000 as calculated using the simulated distribution for cell C10.
Guidelines	The entered <i>targetvalue</i> can be any value.

RiskVariance

Description	RiskVariance (<i>cellref</i> or <i>output/input name</i> , <i>Sim#</i>) returns the variance of the simulated distribution for <i>cellref</i> .
Examples	RiskVariance(A10) returns the variance of the simulated distribution for cell A10.
Guidelines	None.

Reference: Supplemental Functions

The following functions can be used in macro applications based on @RISK to determine the status of a running simulation.

RiskCurrentIter

Description	<i>RiskCurrentIter()</i> returns the current iteration of an executing simulation. No arguments are required.
Examples	None.
Guidelines	None.

RiskCurrentSim

Description	<i>RiskCurrentSim()</i> returns the current simulation number. No arguments are required.
Examples	None.
Guidelines	None.

Reference: Graphing Function

The @RISK function *RiskResultsGraph* will automatically place a graph of simulation results wherever it is used in a spreadsheet. For example, =*RiskResultsGraph* (A10) would place a graph of the simulated distribution for A10 directly in your spreadsheet at the function's location at the end of a simulation. Additional optional arguments to *RiskResultsGraph* allow you to select the type of graph you want to create, its format, scaling and other options.

This function may also be called from the @RISK macro language to generate graphs in Excel in custom @RISK applications.

RiskResultsGraph

Description	<i>RiskResultsGraph</i> (<i>cellRef</i> or <i>output/input name</i> , <i>locationCellRange</i> , <i>graphType</i> , <i>xlFormat</i> , <i>leftdelimiter</i> , <i>rightdelimiter</i> , <i>xMin</i> , <i>xMax</i> , <i>xScale</i> , <i>Title</i> , <i>Sim#</i>) adds a graph of simulation results to a worksheet. The graphs generated are the same as generated in the @RISK-Results window. Many arguments to this function are optional. If optional arguments are not entered, RiskResultsGraph creates a graph using the current default settings in the @RISK Results window for any omitted argument.
Examples	RiskResultsGraph(A10) generates a graph of the simulation results for cell A10 as a Excel format graph at the location of the function, using the default graph type (histogram, cumulative ascending or cumulative descending). RiskResultsGraph(A10,C10:M30,1,TRUE,1,99) generates a graph of the simulation results for cell A10 in the range C10:M30 in Excel format as a histogram, and sets the left and right delimiters at the 1% and 99% values, respectively.
Guidelines	<i>cellRef</i> is any valid Excel cell reference. Either a <i>cellRef</i> or a <i>output/input name</i> argument needs to be included in a RiskResultsGraph function. When <i>cellRef</i> is entered, the results to be graphed depend on the following: If there is a RiskOutput function in <i>cellRef</i> , the simulation results for this output will be graphed. If there is no RiskOutput function in <i>cellRef</i> but there is a distribution function, RiskResultsGraph will graph the collected samples for this input. If there is no RiskOutput and no distribution function in <i>cellRef</i> , a RiskOutput function is automatically added and this output is graphed by RiskResultsGraph. <i>locationCellRange</i> is any valid Excel cell range. The created graph will be located in and sized according to this cell range. <i>GraphType</i> (optional) argument is one of the following constants: 0 for histogram 1 for cumulative ascending graph 2 for cumulative descending graph

	<p>3 for tornado graph of regression sensitivity results</p> <p>4 for tornado graph of correlation sensitivity results</p> <p>5 for a summary graph of the output range that includes cellRef</p> <p><i>XIFormat</i> (optional) specifies if the graph will be created as an Excel format chart. Enter TRUE for an Excel format chart, or enter FALSE or leave blank for an Excel format chart.</p> <p><i>LeftXdelimiter</i> (optional) specifies the location of the left delimiter on the graph in % for histograms and cumulative graphs. LeftXdelimiter is a value from 0 to 100.</p> <p><i>RightXdelimiter</i> (optional) specifies the location of the right delimiter on the graph in % for histograms and cumulative graphs. RightXdelimiter is a value from 0 to 100.</p> <p><i>Xmin</i> (optional) specifies the minimum value for the X axis in unscaled units.</p> <p><i>XMax</i> (optional) specifies the maximum value for the X axis in unscaled units.</p> <p><i>Xscale</i> (optional) specifies the scale factor for the X axis. Xscale is an integer value representing the power of 10 used to convert the x-axis values when labeling the axis. For example, a Xscale of 3 would specify that values would be shown in thousands.</p> <p><i>Title</i> (optional) specifies the graph title shown on the graph. A string in quotes or cell reference containing the title can be entered.</p> <p><i>Sim#</i> (optional) specifies simulation number for which results are to be graphed when multiple simulations are run.</p>
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Reference: @RISK Macros

Overview

The @RISK functions and types accessible by Excel VBA programmers fall into two general categories. The first category allows you to automate the process of editing @RISK settings using code. For example, you might wish to open all the .RSK files in a given folder, change their @RISK settings, and save them. Or perhaps you want to make a custom settings interface, which shields other users from certain details. The second category of functions and types allows you to start and control an @RISK simulation and get simulation results. For example, you may wish to run multiple simulations, one after another, and compare the results between each.

Organization

This section, **Overview**, details how to use the @RISK VBA functions and variables, how to specify @RISK settings, and how to run simulations from VBA. For more detailed information, all the documentation for the available variables and functions is provided in the on-line help file RiskMacro.CHM and in PDF format in the file RiskMacro.PDF.

Using the VBA Functions

To use any of the functions, types, and constants described here, you must first make a “reference” to the @RISK add-in from within your VBA application. First, make sure @RISK is loaded in Excel. Next, from within your VBA module, choose the “Tools” menu’s “References...” option. This will bring up a dialog list of all the available references. Make sure RISK.XLA is checked as a reference.

Macro Example Files

Two example files – **RiskMacro.XLS** and **FitMacro.XLS** – illustrate the use of @RISK functions and types in VBA. They are located in the EXAMPLES folder in your RISK45 directory. RiskMacro.XLS shows how to use @RISK macro functions to run simulations and retrieve simulation results. FitMacro.XLS illustrates the use of @RISK VBA functions to fit probability distributions to data.

Macros from Earlier Versions of @RISK

Earlier versions of @RISK contained macro commands based on the Excel 4-style macro language where commands were placed in an Excel macro sheet. These macro commands are not available in @RISK 4.5 and macro programs that use them need to be translated to the new VBA macro functions described in this chapter. In addition, programs controlling @RISK for Excel developed using the @RISK 3.5 Object Library need to be translated to the new VBA macro functions described in this chapter. The @RISK 3.5 Object Library is not supported in @RISK 4.5. Please contact Palisade for assistance translating applications developed using earlier versions of @RISK.

Using VBA to Modify @RISK Settings and Enter Outputs

Public Variable Type Used for @RISK Settings

The VBA control of the @RISK settings is based on a public defined variable type, which has been designed to closely match the user interface of @RISK. Before reading this guide, you should be familiar with the @RISK 4.5 Excel interface.

The defined public type **RiskSettingsType** contains all the @RISK settings (such as number of iterations, the sampling type, etc.).

Defining @RISK Settings Using Code

There are several public functions that @RISK provides for retrieving, copying, and storing @RISK settings:

- ◆ The **RiskGetSettings** function will read the current @RISK settings and put them into a RiskSettingsType variable.
- ◆ The **RiskSetSettings** function sets the @RISK settings equal to the information in a RiskSettingsType variable. @RISK settings are not saved on disk until a .RSK file is saved using **RiskSaveSimulation**. Keep in mind, changes made to a RiskSettingsType variable will not affect a simulation unless you have called **RiskSetSettings**.
- ◆ The **RiskGetSettingsDefaults** function will fill a RiskSettingsType variable with a set of default settings. These are the same settings a user would see when the @RISK settings toolbar button is pressed for a model with no current @RISK settings.

Each of these functions is discussed in detail in the in the on-line help file RiskMacro.CHM and in PDF format in the file RiskMacro.PDF.

Adding Outputs and Distributions from VBA

Simulation outputs can be defined from VBA using the **RiskAddOutput** function. Using this function individual output cells or output ranges can be defined. Outputs may also be added simply by modifying a cell's formula from VBA to include the desired **RiskOutput** function. This same approach can be used for defining probability distributions or adding @RISK statistics functions. Since @RISK functions are custom Excel functions, they may be added directly to cell formulas from VBA without using a custom @RISK macro command.

Fitting Distributions to Data from VBA

Users of @RISK Professional and Industrial can fit probability distributions to data using VBA and a set of functions for performing fits and getting fit results. The defined public type **RiskFitType** contains the data and settings for a fit that is to be performed. The function **RiskFitDistributions** performs a fit using the information from a **RiskFitType** variable. The function **RiskFitGetFunction** returns the best fitting distribution and arguments based on a specified test or for a specified distribution type. Other functions, such as **RiskFitGetStats**, **RiskFitGetPercentile** and **RiskFitGetTestResults** return specific information about the fit results.

Using VBA to Run Simulations, Get Results and Generate Reports

Simulating with Macros

You can start a simulation by calling the **RiskSimulate** function. See the description of **RiskSimulate** in the **Public Function Reference** for more details.

During the simulation, you can specify four different macros to run at different times during the simulation process. The macros you write must be declared as public subroutines which take no arguments. The **BeforeSimMacro** runs when the simulation begins. In a similar manner, the **AfterSimMacro** runs when the simulation ends.

The two macros **BeforeRecalcMacro** and **AfterRecalcMacro** are called each time @RISK recalculates the spreadsheet. The **BeforeRecalcMacro** is called after @RISK has placed new sampled values into the spreadsheet model, but before Excel is recalculated with these values. This type of macro is useful if you want to modify these values before the calculation occurs. The **AfterRecalcMacro** is called just after @RISK recalculates the spreadsheet model, but before the output value is stored internally. This type of macro is useful if you want to modify the output value before @RISK uses it internally.

Results and Reporting Macros

Functions such as **RiskGetStats**, **RiskGetData** and **RiskGetRegression** allow you to access simulation statistics, data and sensitivities directly in variables in your VBA program. The defined public type **RiskStatsType** contains all the @RISK statistics on simulation results (such as mean, standard deviation, etc.).

Simulation reports can be generated using the **RiskGenerateReports** function. Any combination of available reports may be selected. In addition, the **RiskResultsGraph** function allows a specific graph of simulation results to be placed at a desired location in Excel.

Additional simulation results may be reported using @RISK statistics functions and template reports. These reports are created by placing the appropriate @RISK functions at any location in a worksheet. These functions can be added directly from VBA by modifying a cell's formula to include the desired @RISK function.

A template sheet causes a new report to be generated as each simulation is run. A template sheet name can be specified using the **TemplateSheetName** variable in the **RiskSettingsType**. To learn more about templates, see **the Report Settings Command** in **Chapter 7: @RISK Reference - @RISK Add-in Menu commands**.

Using VBA to Run Advanced Analyses

Each of the Advanced Analyses in @RISK Professional and Industrial can be setup and executed from macros. For example, **RiskGoalSeekSimulate** runs an @RISK Goal Seek, while **RiskAdvSensitivitySimulate** runs an @RISK Advanced Sensitivity Analysis. For more information on each available advanced analysis, see the **Advanced Analyses Menu** in the **Reference: @RISK Add-in Menu Commands** section of this manual.

Using the VBA Functions for Advanced Analyses

To use any of the functions, types, and constants for the @RISK Advanced Analyses, you must first make a “reference” to the @RISK Advanced Tools add-in from within your VBA application. First, make sure @RISK is loaded in Excel. Next, from within your VBA module, choose the “Tools” menu’s “References...” option. This will bring up a dialog list of all the available references. Make sure ADVTOOLS.XLA is checked as a reference.

Appendix A: Sampling Methods

Sampling is used in an @RISK simulation to generate possible values from probability distribution functions. These sets of possible values are then used to evaluate your Excel worksheet. Because of this, sampling is the basis for the hundreds or thousands of "what-if" scenarios @RISK calculates for your worksheet. Each set of samples represents a possible combination of input values which could occur. Choosing a sampling method affects both the quality of your results and the length of time necessary to simulate your worksheet.

What is Sampling?

Sampling is the process by which values are randomly drawn from input probability distributions. Probability distributions are represented in @RISK by probability distribution functions and sampling is performed by the @RISK program. Sampling in a simulation is done repetitively, with one sample drawn every iteration from each input probability distribution. With enough iterations, the sampled values for a probability distribution become distributed in a manner which approximates the known input probability distribution. The statistics of the sampled distribution (mean, standard deviation and higher moments) approximate the true statistics input for the distribution. The graph of the sampled distribution will even look like a graph of the true input distribution.

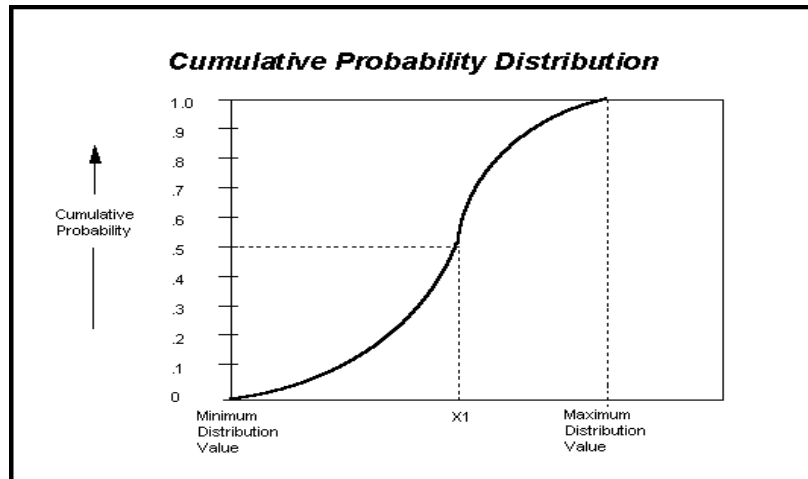
Statisticians and practitioners have developed several techniques for drawing random samples. The important factor to examine when evaluating sampling techniques is the number of iterations required to accurately recreate an input distribution through sampling. Accurate results for output distributions depend on a complete sampling of input distributions. If one sampling method requires more iterations and longer simulation runtimes than another to approximate input distributions, it is the less "efficient" method.

The two methods of sampling used in @RISK — Monte Carlo sampling and Latin Hypercube sampling — differ in the number of iterations required until sampled values approximate input distributions. Monte Carlo sampling often requires a large number of samples to approximate an input distribution, especially if the input distribution is highly skewed or has some outcomes of low probability. Latin Hypercube sampling, a new sampling technique used in @RISK, forces the samples drawn to

correspond more closely with the input distribution and thus converges faster on the true statistics of the input distribution.

Cumulative Distribution

It is often helpful, when reviewing different sampling methods, to first understand the concept of a cumulative distribution. Any probability distribution may be expressed in cumulative form. A cumulative curve is typically scaled from 0 to 1 on the Y-axis, with Y-axis values representing the cumulative probability up to the corresponding X-axis value.



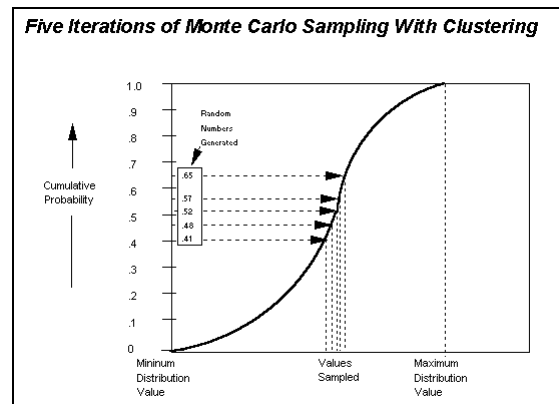
In the cumulative curve above, the .5 cumulative value is the point of 50% cumulative probability (.5 = 50%). Fifty percent of the values in the distribution fall below this median value and 50% are above. The 0 cumulative value is the minimum value (0% of the values will fall below this point) and the 1.0 cumulative value is the maximum value (100% of the values will fall below this point).

Why is this cumulative curve so important to understanding sampling? The 0 to 1.0 scale of the cumulative curve is the range of the possible random numbers generated during sampling. In a typical Monte Carlo sampling sequence, the computer will generate a random number between 0 and 1 — with any number in the range equally likely to occur. This random number is then used to select a value from the cumulative curve. For the example above, if a random number of .5 was generated during sampling, the value sampled for the distribution shown would be X1. As the shape of the cumulative curve is based on the shape of the input probability distribution, more likely outcomes will be more likely to be sampled. The more likely outcomes are in the range where the cumulative curve is the "steepest".

Monte Carlo Sampling

Monte Carlo sampling refers to the traditional technique for using random or pseudo-random numbers to sample from a probability distribution. The term Monte Carlo was introduced during World War II as a code name for simulation of problems associated with development of the atomic bomb. Today, Monte Carlo techniques are applied to a wide variety of complex problems involving random behavior. A wide variety of algorithms are available for generating random samples from different types of probability distributions.

Monte Carlo sampling techniques are entirely random — that is, any given sample may fall anywhere within the range of the input distribution. Samples, of course, are more likely to be drawn in areas of the distribution which have higher probabilities of occurrence. In the cumulative distribution shown earlier, each Monte Carlo sample uses a new random number between 0 and 1. With enough iterations, Monte Carlo sampling "recreates" the input distributions through sampling. A problem of clustering, however, arises when a small number of iterations are performed.



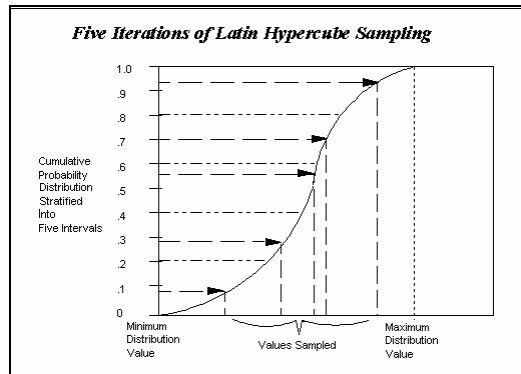
In the illustration shown here, each of the 5 samples drawn falls in the middle of the distribution. The values in the outer ranges of the distribution are not represented in the samples and thus their impact on your results is not included in your simulation output.

Clustering becomes especially pronounced when a distribution includes low probability outcomes which could have a major impact on your results. It is important to include the effects of these low probability outcomes. To do this, these outcomes must be sampled. But, if their probability is low enough, a small number of Monte Carlo iterations may not sample sufficient quantities of these outcomes to accurately represent their probability. This problem has led to the

development of stratified sampling techniques such as the Latin Hypercube sampling used in @RISK.

Latin Hypercube Sampling

Latin Hypercube sampling is a recent development in sampling technology designed to accurately recreate the input distribution through sampling in fewer iterations when compared with the Monte Carlo method. The key to Latin Hypercube sampling is stratification of the input probability distributions. Stratification divides the cumulative curve into equal intervals on the cumulative probability scale (0 to 1.0). A sample is then randomly taken from each interval or "stratification" of the input distribution. Sampling is forced to represent values in each interval, and thus, is forced to recreate the input probability distribution.



In the illustration above, the cumulative curve has been divided into 5 intervals. During sampling, a sample is drawn from each interval. Compare this to the 5 clustered samples drawn using the Monte Carlo method. With Latin Hypercube, the samples more accurately reflect the distribution of values in the input probability distribution.

The technique being used during Latin Hypercube sampling is "sampling without replacement". The number of stratifications of the cumulative distribution is equal to the number of iterations performed. In the example above there were 5 iterations and thus 5 stratifications were made to the cumulative distribution. A sample is taken from each stratification. However, once a sample is taken from a stratification, this stratification is not sampled from again — its value is already represented in the sampled set.

How does sampling within a given stratification occur? In effect, @RISK chooses a stratification for sampling, then randomly chooses value from within the selected stratification.

***Latin Hypercube
and Low
Probability
Outcomes***

When using the Latin Hypercube technique to sample from multiple variables, it is important to maintain independence between variables. The values sampled for one variable need to be independent of those sampled for another (unless, of course, you explicitly want them correlated). This independence is maintained by randomly selecting the interval to draw a sample from for each variable. In a given iteration, Variable #1 may be sampled from stratification #4, Variable #2 may be sampled from stratification #22, and so on. This preserves randomness and independence and avoids unwanted correlation between variables.

As a more efficient sampling method, Latin Hypercube offers great benefits in terms of increased sampling efficiency and faster runtimes (due to fewer iterations). These gains are especially noticeable in a PC based simulation environment such as @RISK. Latin Hypercube also aids the analysis of situations where low probability outcomes are represented in input probability distributions. By forcing the sampling of the simulation to include the outlying events, Latin Hypercube sampling assures they are accurately represented in your simulation outputs.

When low probability outcomes are very important it often helps to run an analysis which just simulates the contribution to the output distribution from the low probability events. In this case the model simulates only the occurrence of low probability outcomes — they are set to 100% probability. Through this you will isolate those outcomes and directly study the results they generate.

***Testing the
Techniques***

The concept of convergence is used to test a sampling method. At the point of convergence, the output distributions are stable (additional iterations do not markedly change the shape or statistics of the sampled distribution). The sample mean versus the true mean is typically a measure of convergence, but skewness, percentile probabilities and other statistics are often used as well.

@RISK provides a good environment for testing the speed at which the two available sampling techniques converge on an input distribution. Run an equal number of iterations with each of the sampling techniques while selecting an input distribution @function as a simulation output. Using the built-in Convergence Monitoring capability in @RISK, see how many iterations it takes the percentiles, mean and standard deviation to stabilize. It should be evident that Latin Hypercube sampling converges faster on the true distributions when compared with Monte Carlo sampling.

More About Sampling Techniques

The academic and technical literature has addressed both Monte Carlo and Latin Hypercube sampling. Any of the references to simulation in the *Recommended Readings* give an introduction to Monte Carlo sampling. References which specifically address Latin Hypercube sampling are included in a separate section.

Appendix B: Using @RISK With Other DecisionTools®

Palisade's DecisionTools Suite is a complete set of decision analysis solutions for Microsoft Windows. With the introduction of DecisionTools, Palisade brings you a decision-making suite whose components combine to take full advantage of the power of your spreadsheet software.

The DecisionTools Suite

The DecisionTools Suite focuses on providing advanced tools for any decision, from risk analysis to sensitivity analysis to distribution fitting. Software packaged with the DecisionTools Suite includes:

- **@RISK** — *risk analysis using Monte-Carlo simulation*
- **TopRank®** — *sensitivity analysis*
- **BestFit®** — *distribution fitting*
- **PrecisionTree®** — *decision analysis with decision trees and influence diagrams*
- **RISKview™** — *distribution viewing companion*

<p><i>Note: When you purchase the DecisionTools Suite, all the features of BestFit and RISKview come fully integrated into your copy of @RISK Professional that comes with the Suite.</i></p>
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While all the tools listed above can be purchased and used separately, they become more powerful when used together. Analyze historical and fit data for use in an @RISK model. Or use TopRank to determine which variables to define in your @RISK model.

This chapter explains many of the ways the components of the DecisionTools suite interact and how they will make your decision making easier and more effective.

Note: Palisade also offers a version of @RISK for Microsoft Project. @RISK for Project allows you to run risk analyses on project schedules created in Microsoft Project, the leading software package for project management. Contact Palisade for more information on this exciting implementation of @RISK!

Purchasing Information

All of the software mentioned here, including the DecisionTools Suite, can be purchased directly from Palisade Corporation. To place an order or receive more information, please contact the technical sales department at Palisade Corporation using one of the following methods:

- *Telephone us at (800) 432-7475 (U.S. only) or (607) 277-8000 any weekday from 8:30 AM to 5:30 PM, EST*
- *Fax us at (607) 277-8001*
- *E-mail us at sales@palisade.com*
- *Visit us on the World Wide Web at <http://www.palisade.com>*
- *Mail us a letter at*

**Technical Sales
Palisade Corporation
31 Decker Road
Newfield, NY 14867**

If you want to contact Palisade Europe:

- *E-mail us at sales@palisade-europe.com.*
- *Telephone us at +44 (0)207 426 9950 (UK).*
- *Fax us at +44 (0)207 375 1229 (UK).*
- *Mail us a letter at:*

**Palisade Europe
The Blue House, Unit 1
30 Calvin Street
London E1 6NW UK**

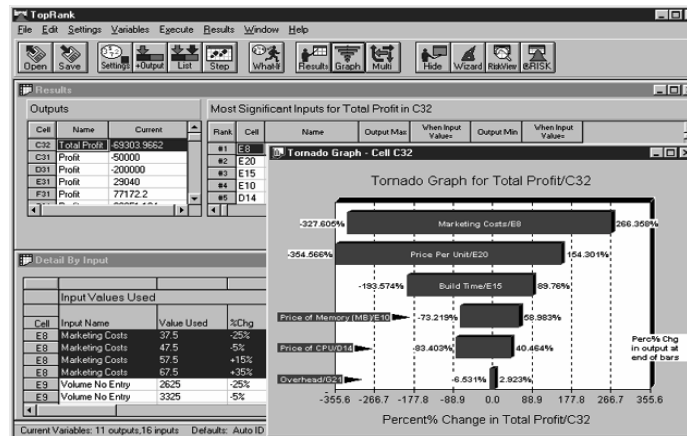
Palisade's DecisionTools Case Study

The Excelsior Electronics company currently makes desktop computers. They are working on a laptop computer, the Excelsior 5000, and want to know whether or not the company will profit from this venture. They built a spreadsheet model which spans the next two years, each column representing one month. The model takes into account production costs, marketing, shipping, price per unit, units sold, etc. The bottom line for each month is "Profit". Excelsior expects some initial setbacks on this venture, but as long as they are not too great and profits are up towards the end of two years, they will go ahead with the E5000.

Run TopRank First, Then @RISK

TopRank is used on the model to find the critical variables. The "Profit" cells are selected as outputs, and an automatic What-if analysis is run. The results quickly show there are five variables (out of many more) that have the most impact on profits: price per unit, marketing costs, build time, price of memory, and price of CPU chips. Excelsior decides to concentrate on these variables.

**TopRank
Identifies Key
Factors for New
Computer
Project**



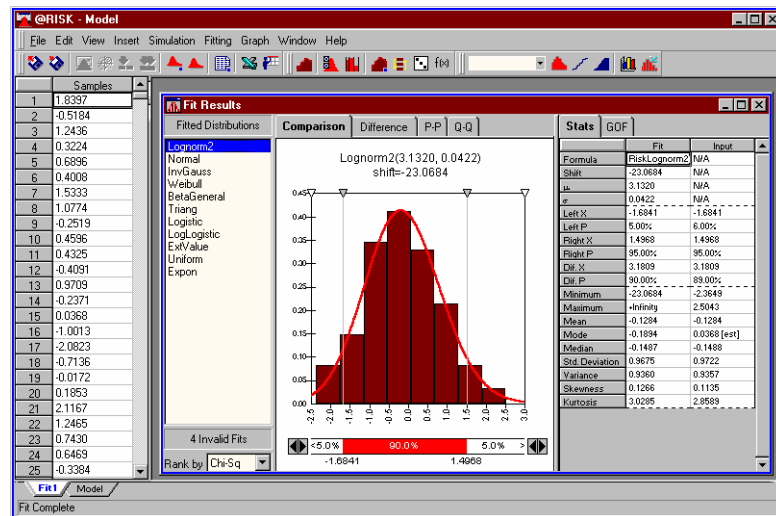
Next, Assess Probabilities

Distribution functions are needed to replace the five variables in the spreadsheet model. Normal distributions are used for price per unit and build time, based on internal decisions and information from Excelsior's manufacturing division. At a marketing department meeting, @RISK's Artist window is used by managers to draw distribution curves which represent the range of possible marketing costs. Once a hand-drawn distribution is agreed upon, the **Fit Curve** command provides an @RISK distribution function for use in the model.

Add Distribution Fitting

Research is done to get weekly price quotes for memory and CPU's over the past two years. This data is fed into @RISK's distribution fitting and distributions are fitted to the data. Confidence level information confirms that the distributions are good fits, and the resulting @RISK distribution functions are pasted into the model.

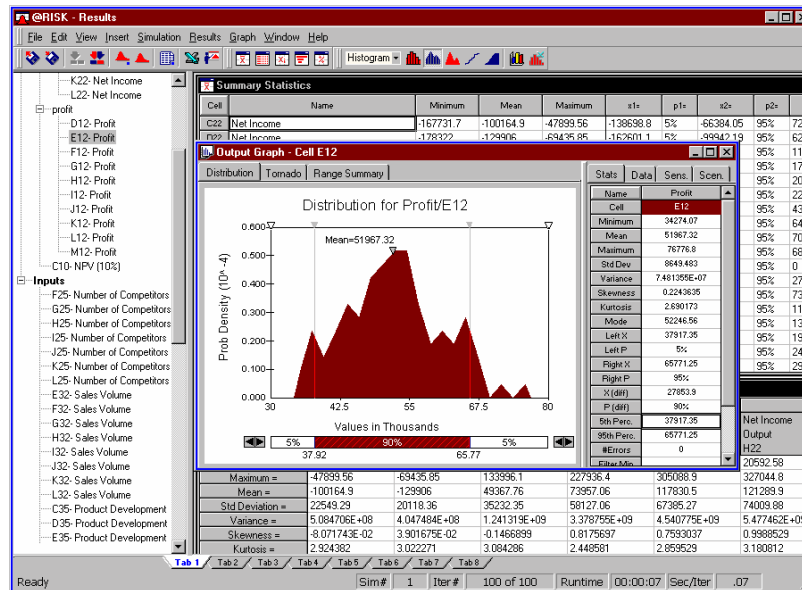
Fit Historical Data to Distributions



Simulate with @RISK

Once all the @RISK functions are in place, the "Profit" cells are selected as outputs and a simulation is run. Overall, the results look promising. Although there will be losses initially, there is an 85% chance they will make an acceptable profit, and a 25% chance the venture will generate more revenue than they had initially assumed! The Excelsior 5000 project is given the go-ahead.

@RISK
*Simulates Profit
From Laptop
Sales*



Decide with PrecisionTree

Excelsior Electronics had assumed they would sell and distribute the Excelsior 5000 themselves. However they could use various catalogs and computer warehouses to distribute their product. A decision tree model is built using PrecisionTree, taking into account unit prices, sales volume, and other critical factors for direct sales versus catalog sales. A Decision Analysis is run and PrecisionTree suggests using catalogs and warehouses. Excelsior Electronics puts that plan into full motion.

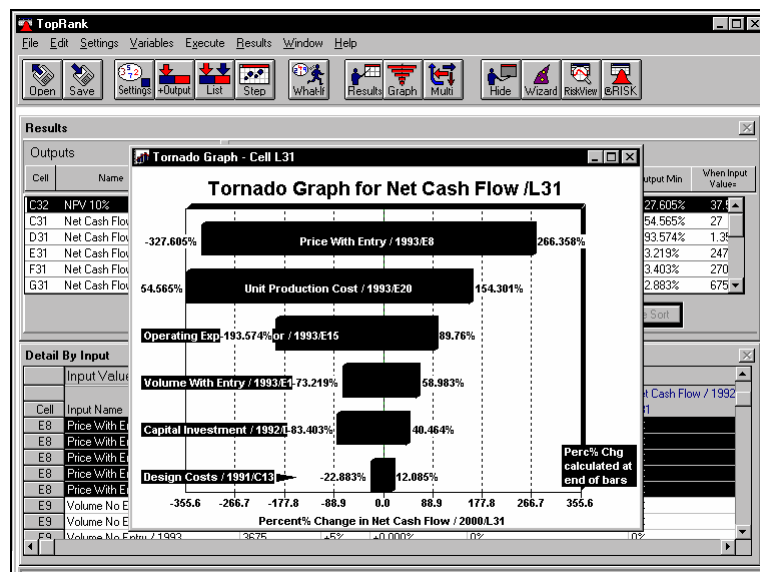
Introduction to TopRank®

TopRank is the ultimate What-if tool for spreadsheets from Palisade Corporation. TopRank greatly enhances the standard What-if and data table capabilities found in your spreadsheet. In addition, you can easily step up to powerful risk analysis with its companion package, @RISK.

TopRank and What-if Analysis

TopRank helps you find out which spreadsheet value(s) or variable(s) affects your results the most — an automated What-if or sensitivity analysis. You also can have TopRank automatically try any number of values for a variable — a data table — and tell you the results calculated at each value. TopRank also tries all possible combinations of values for a set of variables (a Multi-Way What-if analysis), giving you the results calculated for each combination.

*TopRank for
Excel*



Running a What-if or sensitivity analysis is a key component of making any decision based on a spreadsheet. This analysis identifies which variables affect your results the most. It shows you those factors you should be most concerned with as you 1) gather more data and refine your model and 2) manage and implement the situation described by the model.

TopRank is a spreadsheet add-in for both Microsoft Excel and Lotus 1-2-3 for Windows. It can be used with any pre-existing or new spreadsheet. To set up your What-if analyses, TopRank adds new custom “Vary” functions to the spreadsheet function set. These functions specify how the values in your spreadsheet can be varied in a What-if analysis; for example, +10% and -10%, +1000 and -500, or according to a table of values you’ve entered.

TopRank can also run a fully automatic What-if analysis. It uses powerful auditing technology to find all possible values in your spreadsheet which could affect your results. It can then change all these possible values automatically and find out which is most significant in determining your results.

TopRank Applications

TopRank applications are the same as spreadsheet applications. If you can build your model in a spreadsheet, you can use TopRank to analyze it. Businesses use TopRank to identify the critical factors — price, up front investment amount, sales volume or overhead — that most affect the success of their new product. Engineers use TopRank to show them the individual product components whose quality most affects final product production rates. A loan officer can have TopRank quickly run her model at all possible interest rate, loan principle amount and down payment combinations and review results for each possible scenario. Whether your application is in business, science, engineering, accounting or another field, TopRank can work for you to identify the critical variables which affect your results.

Modeling Features

Why TopRank?

As an add-in to Microsoft Excel and Lotus 1-2-3, TopRank links directly to your spreadsheet to add What-if analysis capabilities. The TopRank system provides all the necessary tools for conducting a What-if analysis on any spreadsheet model. And TopRank works in a style you are familiar with — Excel style menus and functions.

What-if analysis and Data Tables are functions that can be performed directly in your spreadsheet, but only in a manual, unstructured format. Simply changing a cell value in your spreadsheet and calculating a new result is a basic What-if analysis. And a Data Table which gives a result for each combination of two values can also be built in your spreadsheet. TopRank, however, performs these tasks automatically and analyzes their results for you. It instantly performs What-ifs on all possible values in your spreadsheet which could affect your result, instead of requiring you to individually change values

Multi-Way What-if Analysis

and recalculate. It then tells you what spreadsheet value is most significant in determining your result.

TopRank also runs data table combinations automatically, without requiring you to set up tables in your spreadsheet. Combine more than two variables in its Multi-Way What-if analysis — you can generate combinations of any number of variables — and rank your combinations by their affect on your results. You can perform these sophisticated and automated analyses quickly, as TopRank keeps track of all the values and combinations it tries, and their results, separate from your spreadsheet. By taking an automated approach, TopRank gives you What-if and Multi-Way What-if results almost instantly. Even the least experienced modeler can get powerful analysis results.

TopRank Functions

TopRank defines variations in spreadsheet values using functions. To do this, TopRank has added a set of new functions to the Excel function set, each of which specifies a type of variation for your values. These functions include:

- **Vary** and **AutoVary** functions which, during a What-if analysis, change a spreadsheet value across a + and - range you define.
- **VaryTable** functions which, during a What-if analysis, substitute each of a table of values for a spreadsheet value.

TopRank uses functions to change spreadsheet values during a What-if analysis and keeps track of the results calculated for each value change. These results are then ranked by the amount of change from the original expected results. Then functions which caused the greatest change are identified as the most critical to the model.

TopRank Pro also includes over 30 probability distribution functions found in @RISK. These functions can be used along with Vary functions to describe variation in spreadsheet values.

How are TopRank Functions Entered?

TopRank functions are entered wherever you want to try different values in a What-if analysis. The functions can be added to any number of cells in a spreadsheet and can include arguments which are cell references and expressions — providing extreme flexibility in defining variation in value in spreadsheet models.

In addition to adding Vary functions yourself, TopRank can automatically enter Vary functions for you. Use this powerful feature to quickly analyze your spreadsheets without manually identifying values to vary and typing in functions.

Automated What-if's

When automatically entering Vary functions, TopRank traces back through your spreadsheet and finds all possible values which could affect the result cell you identify. As it finds a possible value, it substitutes in an "AutoVary" function with the default variation parameters (such as +10% and -10%) you've selected. With a set of AutoVary functions inserted, TopRank can then run its What-if analysis and rank the values which could affect your results by their importance.

With TopRank, you can step through your Vary and AutoVary functions and change the variation each function specifies. As a default you can use a -10% and +10% variation, but for a certain value you may feel that a -20% and +30% change is possible. You can also select to not have a value varied — as in some cases a spreadsheet value is fixed and could never be changed.

Running a What-if Analysis

During its analysis TopRank individually changes values for each Vary function and recalculates your spreadsheet using each new value. Each time it recalculates, it collects the new value calculated in each result cell. This process of changing value and recalculating is repeated for each Vary and VaryTable function. The number of recalculations performed depends on the number of Vary functions entered, the number of steps (i.e., values across the min-max range) you want TopRank to try for each function, the number of VaryTable functions entered, and the values in each table used.

TopRank Results

TopRank ranks all varied values by their impact on each result cell or output you've selected. Impact is defined as the amount of change in the output value that was calculated when the input value was changed. If, for example, the result of your spreadsheet model was 100 prior to changing values, and the result was 150 when an input changed, there is a +50% change in results caused by changing the input.

TopRank results can be view graphically in a Tornado, Spider or Sensitivity graph. These graphs summarize your results to easily show the most important inputs for your results.

Using @RISK with TopRank

What-if analysis is often the first analysis performed on a spreadsheet. Its results lead to a further refinement of the model, additional analyses and ultimately, a final decision based on the best model possible. Risk analysis, a powerful analytical technique available using TopRank's companion product, @RISK, is often the next analysis performed on a spreadsheet after a What-if analysis.

Moving from What-if to Simulation

A What-if analysis initially identifies what's important in your model. You can then focus on these important components and better estimate what their values could be. Usually, however, there are several or more of these important uncertain components, and, in reality, they could all vary at the same time. To analyze an uncertain model such as this you need risk analysis or Monte Carlo simulation. Risk analysis varies all uncertain inputs simultaneously — just as they do in real life — and builds a range and distribution of the possible results that could occur.

With risk analysis, inputs are described with a probability distribution — such as normal, lognormal, beta or binomial. This is a much more detailed description of the uncertainty present in an input's value than a simple + or - percentage variation. A probability distribution shows both the range of values possible for an input and the likelihood of occurrence of any value in the range. Simulation combines these input distributions to generate both a range of possible results from your model and the likelihood of any result occurring.

Using What-if Definitions in a Risk Analysis

The simple + and - change defined by a Vary function in a What-if analysis can be used directly in risk analysis. @RISK actually samples your Vary functions directly in a risk analysis.

The values sampled by @RISK from Vary and VaryTable functions during a simulation depend on either distribution argument entered for the function or the default distribution setting used in TopRank. For example, the TopRank function **RiskVary(100,-10,+10)**, using a default distribution setting of Uniform and a default range type of +/- percentage, is sampled like the @RISK distribution **RiskUniform(90,110)**. VaryTable functions from TopRank are sampled as RiskDuniform functions in @RISK.

The Differences Between TopRank and @RISK

TopRank and @RISK share many common features, so it's easy to think that they perform the same functions. In fact, the two programs perform different, but complementary, tasks. Don't ask yourself "Which should I use, @RISK or TopRank?", ask yourself "Shouldn't I use both?"

The Similarities

Both @RISK and TopRank are add-ins for analysis of models designed in spreadsheets. By using special spreadsheet formulas, both programs explore how uncertainty affects your model, and thus the decisions you make. And, a common user-interface guarantees a smooth transition between the two products: one learning curve instead of two!

The Differences

There are three main areas where @RISK and TopRank differ:

- *Inputs* — *how uncertainty is defined in your model*
- *Calculations* — *what happens during an analysis*
- *Results* — *what types of answers the analyses provide*

Inputs

@RISK defines uncertainty in your model using probability distribution functions. These functions define all the possible values an input can have with a corresponding probability of that value occurring. There are over 30 probability distribution functions available in @RISK.

To define uncertainty in @RISK, you need to assign a distribution function to every value that you think is uncertain. It's up to you, the user, to determine which inputs are uncertain and which distribution function describes the uncertainty.

TopRank defines uncertainty in your model using Vary functions. Vary functions are simple: they define possible values that an input can have without assigning probabilities to those values. There are only two basic Vary functions in TopRank — Vary and VaryTable.

TopRank can automatically define variable cells in your model every time you select and output. You don't need to know which cells are uncertain or important, TopRank identifies those cells for you.

Calculations

@RISK runs a Monte Carlo or Latin Hypercube simulation. For each iteration (or step), every @RISK distribution in the spreadsheet model takes on a new value determined by the probability distribution function. To run a thorough analysis, @RISK needs to run hundreds, sometimes thousands, of iterations.

TopRank runs a single or Multi-Way sensitivity analysis. During the analysis, only one cell (or a small number of cells) varies at a time according to the values defined in the Vary function. With TopRank, only a few iterations are needed to study a large number of uncertain cells.

Results

For each output defined, @RISK produces a probability distribution as an analysis result. The distribution describes which values an output (such as profit) could have, as well as how probable certain outcomes are. For example, @RISK can tell you that there is a 30% chance that your company will not make a profit next quarter.

For each output defined, TopRank tells you which inputs have the largest effect on the output. The results show how much change you can expect in an output when a given input changes by a defined amount. For example, TopRank can tell you that your company's profits are most sensitive to sales volume, and that when sales volume is 1000 units, you will lose \$1 million. So, TopRank told you that to make a profit, you'll need to concentrate on keeping sales volume high.

The most important difference between the two packages is that @RISK studies how the combined uncertainty of all variables affect the output. TopRank only tells you how an individual input (or a small group of inputs) affects the output. So, while TopRank is faster and easier to use, @RISK provides a more detailed, comprehensive look at the problem. **We strongly recommend using TopRank first to determine which variables are the most important. Then, use @RISK to run a comprehensive analysis of your problem for the best possible results.**

Summary

In summary, TopRank tells you what the most important variables are in your model. The results of a TopRank What-if analysis can be used on their own to make better decisions. But, for the most thorough analysis, use TopRank to find the most important variables in your model, then use @RISK to define uncertainty in those variables and run a simulation. TopRank can help you optimize your @RISK simulations by defining uncertainty in only the most important variables, making your simulation faster and more compact.

Introduction to PrecisionTree™

PrecisionTree from Palisade Corporation is a decision analysis add-in to Microsoft Excel. Now you can do something you've never been able to do before - define a decision tree or influence diagram directly in your spreadsheet. PrecisionTree allows you to run a complete decision analysis without leaving the program where your data is - your spreadsheet!

Why You Need Decision Analysis and PrecisionTree

You might wonder if the decisions you make are suitable for decision analysis. If you are looking for a way to structure your decisions to make them more organized and easier to explain to others, you definitely should consider using formal decision analysis.

When faced with a complex decision, decision makers must be able to organize the problem efficiently. They have to consider all possible options by analyzing all available information. In addition, they need to present this information to others in a clear, concise format. PrecisionTree allows decision makers to do all this, and more!

But, what exactly does decision analysis allow you to do? As the decision maker, you can clarify options and rewards, describe uncertainty quantitatively, weigh multiple objectives simultaneously and define risk preferences. All in an Excel spreadsheet.

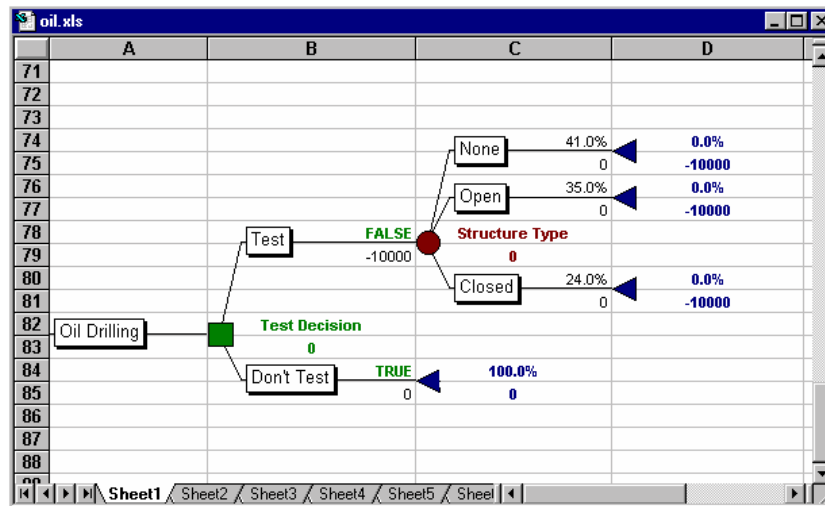
Modeling Features

As an "add-in" to Microsoft Excel, PrecisionTree "links" directly to Excel to add Decision Analysis capabilities. The PrecisionTree system provides all the necessary tools for setting up and analyzing decision trees and influence diagrams. And PrecisionTree works in a style you are familiar with — Excel-style menus and toolbars.

With PrecisionTree, there's no limit to the size tree you can define. Design a tree which spans multiple worksheets in an Excel workbook! PrecisionTree reduces the tree to an easy-to-understand report right in your current workbook.

***PrecisionTree
and Microsoft
Excel***

Decision Tree in PrecisionTree and Excel



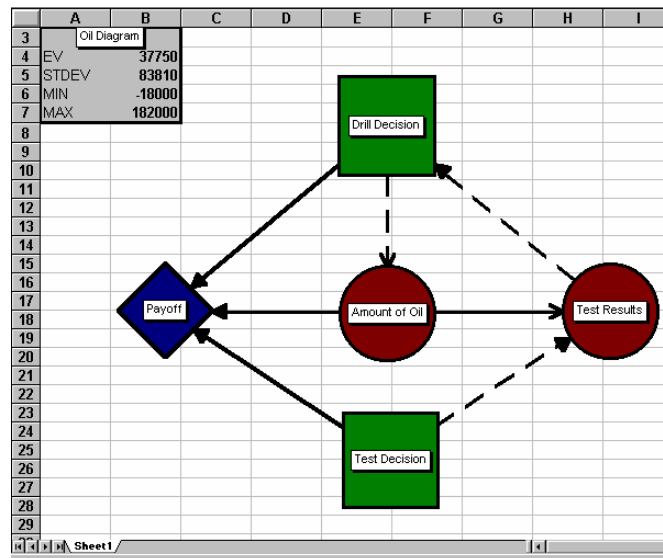
PrecisionTree Nodes

PrecisionTree allows you to define influence diagram and decision tree nodes in Excel spreadsheets. Node types offered by PrecisionTree include:

- *Chance nodes*
- *Decision nodes*
- *End nodes*
- *Logic nodes*
- *Reference nodes*

Values and probabilities for nodes are placed directly in spreadsheet cells, allowing you to easily enter and edit the definition of your decision models.

Influence Diagram in PrecisionTree and Excel



Model Types

PrecisionTree creates both decision trees and influence diagrams. Influence diagrams are excellent for showing the relationship between events and the general structure of a decision clearly and concisely, while decision trees outline the chronological and numerical details of the decision.

Values in Models

In PrecisionTree, all decision model values and probabilities are entered directly in spreadsheet cells, just like other Excel models. PrecisionTree can also link values in a decision model directly to locations you specify in a spreadsheet model. The results of that model are then used as the payoffs for each path through the decision tree.

All calculations of payoffs happen in “real-time” – that is, as you edit your tree, all payoffs and node values are automatically recalculated.

Decision Analysis

PrecisionTree's decision analyses give you straightforward reports including statistical reports, risk profiles and policy suggestions* (*PrecisionTree Pro only). And, decision analysis can produce more qualitative results by helping you understand tradeoffs, conflicts of interest, and important objectives.

All analysis results are reported directly in Excel for easy customization, printing and saving. There's no need to learn a whole new set of formatting commands since all PrecisionTree reports can be modified like any other Excel worksheet or chart.

Sensitivity Analysis

Have you ever wondered which variables matter most in your decision? If so, you need PrecisionTree's sensitivity analysis options. Perform both one and two-way sensitivity analyses and generate Tornado Graphs, spider graphs, strategy region graphs (PrecisionTree Pro only), and more!

For those who need more sophisticated sensitivity analyses, PrecisionTree links directly to TopRank, Palisade Corporation's sensitivity analysis add-in.

Reducing a Tree

Because decision trees can expand as more possible decision options are added, PrecisionTree offers a set of features designed to help you reduce trees to a more manageable size. All nodes can be collapsed, hiding all paths which follow the node from view. A single subtree can be referenced from multiple nodes in other trees, saving the re-entry of the same tree over and over.

Utility Assessment

Sometimes you need help in creating a utility function that is used to factor your attitude towards risk into the calculations in your decision models. PrecisionTree contains features which help you identify your attitude towards risk and create your own utility functions.

Advanced Analysis Capabilities

PrecisionTree offers many advanced analysis options including:

- *Utility functions*
- *Use of multiple worksheets to define trees*
- *Logic nodes*

Using @RISK with PrecisionTree

@RISK is a perfect companion to PrecisionTree. @RISK allows you to 1) quantify the uncertainty that exists in the values and probabilities which define your decision trees, and 2) more accurately describe chance events as a continuous range of possible outcomes. Using this information, @RISK performs a Monte-Carlo simulation on your decision tree, analyzing every possible outcome and graphically illustrating the risks you face.

Using @RISK to Quantify Uncertainty

With @RISK, all uncertain values and probabilities for branches in your decision trees and supporting spreadsheet models can be defined with distribution functions. When a branch from a decision or chance node has an uncertain value, for example, this value can be described by an @RISK distribution function. During a normal decision analysis, the expected value of the distribution function will be used as the value for the branch. The expected value for a path in the tree will be calculated using this value.

However, when a simulation is run using @RISK, a sample will be drawn from each distribution function during each iteration of the simulation. The value of the decision tree and its nodes will then be recalculated using the new set of samples and the results recorded by @RISK. A range of possible values will then be displayed for the decision tree. Instead of seeing a risk profile with a discrete set of possible outcomes and probabilities, a continuous distribution of possible outcomes is generated by @RISK. You can see the chance of any result occurring.

Describing Chance Events as a Continuous Range of Possible Outcomes

In decision trees, chance events must be described in terms of discrete outcomes (a chance node with a finite number of outcome branches). But, in real life, many uncertain events are continuous, meaning that any value between a minima and maxima can occur.

Using @RISK with PrecisionTree makes modeling continuous events easier using distribution functions. And, @RISK functions can make your decision tree smaller and easier to understand!

Methods of Recalculation During a Simulation

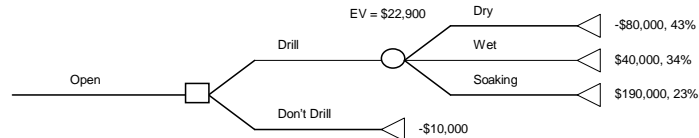
Two options are available for recalculation of a decision model during a simulation performed with @RISK. The first option, *Expected Values of the Model*, causes @RISK to first sample all distribution functions in the model and supporting spreadsheets each iteration, then recalculate the model using the new values to generate a new expected value. Typically the output from the simulation is the cell containing the expected value of the model. At the end of the run an output distribution reflecting the possible range of expected values for the model and their relative likelihood of occurrence is generated.

The second option, *Values of One Sampled Path Through the Model*, causes @RISK to randomly sample a path through the model each iteration of a simulation. The branch to follow from each chance node is randomly selected based on the branch probabilities entered. This method does not require that distribution functions be present in the model; however, if they are used a new sample is generated each iteration and used in path value calculations. The output from the simulation is the cell containing the value of the model, such as the value of the root node of the tree. At the end of the run an output distribution reflecting the possible range of out values for the model and their relative likelihood of occurrence is generated.

Using Probability Distributions in Nodes

Let's take a look at a chance node in an oil drilling decision tree:

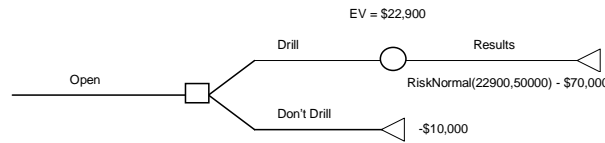
Drilling Decision for Open Test Results



The results of drilling are divided into three discrete outcomes (Dry, Wet and Soaking). But, in reality, the amount of oil found should be described with a continuous distribution. Suppose the amount of money made from drilling follows a lognormal distribution with a mean of \$22900 and a standard deviation of \$50000, or the @RISK distribution =RiskLognorm(22900,50000).

To use this function in the oil drilling model, change the chance node to have only one branch, and the value of the branch is defined by the @RISK function. Here's how the new model should look:

Drilling Decision With a Probability Distribution



During an @RISK simulation, the RiskLognorm function will return random values for the payoff value of the Results node and PrecisionTree will calculate a new expected value for the tree.

Decision Forcing During Simulation

But, what about the decision to Drill or Not Drill? If the expected value of the Drill node changes, the optimum decision could change iteration to iteration. That would imply that we know the outcome of drilling before the decision is made. To avoid this situation, PrecisionTree has an option *Decisions Follow Current Optimal Path* to force decisions before running an @RISK simulation. Every decision node in the tree will be changed to a forced decision node, which causes each decision node to select the decision that's optimal when the command is used. This avoids changes in a decision due to changing a decision tree's values and probabilities during a risk analysis.

Using @RISK to Analyze Decision Options

Value of Perfect Information

There may be times when you want to know the outcome of a chance event before making a decision. You want to know the value of perfect information.

Before running a risk analysis, you know the expected value of the Drill or Don't Drill decision from the value of the Drill Decision node. If you ran a risk analysis on the model without forcing decisions, the return value of the Drill Decision node would reflect the expected value of the decision *if you could perfectly predict the future*. The difference between the two values is the highest price you should pay (perhaps by running more tests) to find out more information before making the decision.

Selecting @RISK Outputs

Running a risk analysis on a decision tree can produce many types of results, depending on the cells in your model you select as outputs. True expected value, the value of perfect information, and path probabilities can be determined.

Start Node

Select the value of a start node of a tree (or the beginning of any subtree) to generate a risk profile from an @RISK simulation. Since @RISK distributions generate a wider range of random variables, the resulting graph will be smoother and more complete than the traditional discrete risk profile.

Appendix C: Glossary

Averse	<i>See risk averse</i>
Continuous Distribution	<p>A probability distribution where any value between the minimum and maximum is possible (has finite probability).</p> <p><i>See discrete distribution</i></p>
Cumulative Distribution	<p>A cumulative distribution, or a cumulative distribution function, is the set of points, each of which equals the integral of a probability distribution starting at the minimum value and ending at the associated value of the random variable.</p> <p><i>See cumulative frequency distribution, probability distribution</i></p>
Cumulative Frequency Distribution	<p>A cumulative frequency distribution is the term for the output and the input cumulative distributions of @RISK. A cumulative distribution is constructed by cumulating the frequency (progressively adding bar heights) across the range of a frequency distribution. A cumulative distribution can be an "upwardly sloping" curve, where the distribution describes the probability of a value less than or equal to any variable value. Alternatively, the cumulative curve may be a "downwardly sloping" curve, where the distribution describes the probability of a value greater than or equal to any variable value.</p> <p><i>See cumulative distribution</i></p>
Dependent Variable	<p>A dependent variable is one that depends in some way on the values of other variables in the model under consideration. In one form, the value of an uncertain dependent variable can be calculated from an equation as a function of other uncertain model variables.</p> <p>Alternatively, the dependent variable may be drawn from a distribution based on the random number which is correlated with a random number used to draw a sample of an independent variable.</p> <p><i>See independent variable</i></p>
Deterministic	<p>The term deterministic indicates that there is no uncertainty associated with a given value or variable.</p> <p><i>See stochastic, risk</i></p>

Discrete Distribution	<p>A probability distribution where only a finite number of discrete values are possible between the minimum and maximum.</p> <p><i>See continuous distribution</i></p>
Event	<p>The term event refers to an outcome or group of outcomes that might result from a given action. For example, if the action is the pitch of a baseball, the possible events might include a hit (with outcomes single, double, triple, home run), an out, a foul ball, a ball, etc.</p>
Expected Value	<p><i>See mean</i></p>
Frequency Distribution	<p>Frequency distribution is the proper term for the output probability distributions and the input histogram distributions (HISTOGRAM) of @RISK. A frequency distribution is constructed from data by arranging values into classes and representing the frequency of occurrence in any class by the height of the bar. The frequency of occurrence corresponds to probability.</p>
Higher Moments	<p>Higher moments are statistics of a probability distribution. The term generally refers to the skewness and kurtosis, the third and fourth moments respectively. The first and second moments are the mean and the standard deviation, respectively.</p> <p><i>See skewness, kurtosis, mean, standard deviation</i></p>
Independent Variable	<p>An independent variable is one that does not depend in any way on the values of any other variable in the model under consideration. The value of an uncertain independent variable is determined by drawing a sample from the appropriate probability distribution. This sample is drawn without regard to any other random sample drawn for any other variable in the model.</p> <p><i>See dependent variable</i></p>
Iteration	<p>An iteration is one recalculation of the user's model during a simulation. A simulation consists of many recalculations or iterations. During each iteration, all uncertain variables are sampled once according to their probability distributions, and the model is recalculated using these sampled values.</p> <p><i>Also known as a simulation trial</i></p>
Kurtosis	<p>Kurtosis is a measure of the shape of a distribution. Kurtosis indicates how flat or peaked the distribution is. The higher the kurtosis value, the more peaked the distribution.</p> <p><i>See skewness</i></p>

Latin Hypercube	<p>Latin Hypercube is a relatively new stratified sampling technique used in simulation modeling. Stratified sampling techniques, as opposed to Monte Carlo type techniques, tend to force convergence of a sampled distribution in fewer samples.</p> <p><i>See Monte Carlo</i></p>
Mean	<p>The mean of a set of values is the sum of all the values in the set divided by the total number of values in the set.</p> <p><i>Synonym: expected value</i></p>
Monte Carlo	<p>Monte Carlo refers to the traditional method of sampling random variables in simulation modeling. Samples are chosen completely randomly across the range of the distribution, thus necessitating large numbers of samples for convergence for highly skewed or long-tailed distributions.</p> <p><i>See Latin Hypercube</i></p>
Most Likely Value	<p>The most likely value or mode is the value that occurs most often in a set of values. In a histogram and a result distribution, it is the center value in the class or bar with the highest probability.</p>
Objective Risk	<p>Objective risk or objective probability refers to a probability value or distribution that is determined by "objective" evidence or accepted theory. The probabilities associated with an objective risk are known with certainty.</p> <p><i>See subjective risk</i></p>
Percentile	<p>A percentile is an increment of the values in a data set. Percentiles divide the data into 100 equal parts, each containing one percent of the total values. The 60th percentile, for example, is the value in the data set for which 60% of the values are below it and 40% are above.</p>
Preference	<p>Preference refers to an individual's choices where many attributes of a decision or object are considered. Risk is an important consideration in personal preference.</p> <p><i>See risk averse</i></p>
Probability	<p>Probability is a measure of how likely a value or event is to occur. It can be measured from simulation data as frequency by calculating the number of occurrences of the value or event divided by the total number of occurrences. This calculation returns a value between 0 and 1 which then can be converted to percentage by multiplying by 100.</p> <p><i>See frequency distribution, probability distribution</i></p>

Probability Distribution	<p>A probability distribution or probability density function is the proper statistical term for a frequency distribution constructed from an infinitely large set of values where the class size is infinitesimally small.</p> <p><i>See frequency distribution</i></p>
Random Number Generator	<p>A random number generator is an algorithm for choosing random numbers, typically in the range of 0 to 1. These random numbers are equivalent to samples drawn from a uniform distribution with a minimum of 0 and a maximum of 1. Such random numbers are the basis for other routines that convert them into samples drawn from specific distribution types.</p> <p><i>See random sample, seed</i></p>
Random Sample	<p>A random sample is a value that has been chosen from a probability distribution describing a random variable. Such a sample is drawn randomly according to a sampling "algorithm". The frequency distribution constructed from a large number of random samples drawn by such an algorithm will closely approximate the probability distribution for which the algorithm was designed.</p>
Range	<p>The range is the absolute difference between the maximum and minimum values in a set of values. The range is the simplest measure of the dispersion or "risk" of a distribution.</p>
@RISK	<p>@RISK (pronounced "at risk") is the name of the Excel Add-In for Risk Analysis described in this User's Guide.</p>
Risk	<p>The term risk refers to uncertainty or variability in the outcome of some event or decision. In many cases the range of possible outcomes can include some that are perceived as a loss or undesirable along with others that are perceived as a gain or desirable. The range of outcomes is often associated with levels of probability of occurrence.</p>
Risk Analysis	<p>Risk Analysis is a general term used to describe any method used to study and understand the risk inherent to a situation of interest. Methods can be quantitative and/or qualitative in nature. @RISK uses a quantitative technique generally referred to as simulation.</p> <p><i>See simulation</i></p>
Risk Averse	<p>Risk averse refers to a general characteristic of individuals with regard to their preference for risk. As the payoff and risk increase, the individual will be less likely to choose a course of action intended to achieve the higher payoff. It is generally assumed that rational individuals are risk averse, although the degree of risk averseness varies from one individual to another. There are situations or ranges of payoffs over which individuals may display the opposite behavior, namely, they will be risk takers.</p>

Sample	<i>See random sample</i>
Seed	<p>The seed is a number that initializes the selection of numbers by a random number generator. Given the same seed, a random number generator will generate the same series of random numbers each time a simulation is run.</p> <p><i>See random number generator</i></p>
Simulation	<p>Simulation is a technique whereby a model, such as an Excel worksheet, is calculated many times with different input values with the intent of getting a complete representation of all possible scenarios that might occur in an uncertain situation.</p>
Skewness	<p>Skewness is a measure of the shape of a distribution. Skewness indicates the degree of asymmetry in a distribution. Skewed distributions have more values to one side of the peak or most likely value — one tail is much longer than the other. A skewness of 0 indicates a symmetric distribution, while a negative skewness means the distribution is skewed to the left. Positive skewness indicates a skew to the right.</p> <p><i>See kurtosis</i></p>
Standard Deviation	<p>The standard deviation is a measure of how widely dispersed the values are in a distribution. Equals the square root of the variance.</p> <p><i>See variance</i></p>
Stochastic	<p>Stochastic is a synonym for uncertain, risky.</p> <p><i>See risk, deterministic</i></p>
Subjective Risk	<p>Subjective risk or subjective probability is a probability value or distribution determined by an individual's best estimate based on personal knowledge, expertise, and experience. New information often causes changes in such estimates. Reasonable individuals may disagree on such estimates.</p> <p><i>See objective risk</i></p>
Summary Graph	<p>A Summary Graph is an output graphic in @RISK that presents simulation results for a range of cells in a Excel worksheet. The Summary Graph takes the underlying distributions for each cell and summarizes them by showing the trend of the means and two measures on either side of the means. These two measures default to the 10th and 90th percentile trends.</p>
Trial	<p>Trial is another term for iteration.</p> <p><i>See iteration</i></p>

Truncation	Truncation is the process by which a user chooses a minimum-maximum range for a random variable that differs from the range indicated by the distribution type of the variable. A truncated distribution has a smaller range than the untruncated distribution because the truncation minimum is greater than the distribution minimum and/or the truncation maximum is less than the distribution maximum.
Uncertainty	<i>See risk</i>
Variable	A variable is a basic model component that can take on more than one value. If the value that actually will occur is not known with certainty, the variable is considered uncertain. A variable, certain or uncertain, may be either dependent or independent. <i>See dependent variable, independent variable</i>
Variance	The variance is a measure of how widely dispersed the values are in a distribution, and thus is an indication of the "risk" of the distribution. It is calculated as the average of the squared deviations about the mean. The variance gives disproportionate weight to "outliers", values that are far away from the mean. The variance is the square of the standard deviation.

Appendix D: Recommended Readings

Readings by Category

The @RISK User's Guide has given you a start on understanding the concepts of Risk Analysis and simulation. If you're interested in finding out more about the Risk Analysis technique and the theory behind it, here are some books and articles which examine various areas in the Risk Analysis field.

Introduction to Risk Analysis

If you are new to Risk Analysis or if you would just like some more background information on the technique, the following books and articles might be helpful:

* Clemen, Robert T. and Reilly, Terrence. Making Hard Decisions with DecisionTools: Duxbury Thomson Learning, 2000.

Hertz, D.B. "Risk Analysis in Capital Investment": HBR Classic, Harvard Business Review, September/October 1979, pp. 169-182.

Hertz, D.B. and Thomas, H. Risk Analysis and Its Applications: John Wiley and Sons, New York, NY, 1983.

Megill, R.E. (Editor). Evaluating and Managing Risk: PennWell Books, Tulsa, OK, 1984.

Megill, R.E. An Introduction to Risk Analysis, 2nd Ed.: PennWell Books, Tulsa, OK, 1985.

Morgan, M. Granger and Henrion, Max, with a chapter by Mitchell Small. Uncertainty: Cambridge University Press, 1990.

Newendorp, P.D. Decision Analysis for Petroleum Exploration: Petroleum Publishing Company, Tulsa, Okla., 1975.

Raiffa, H. Decision Analysis: Addison-Wesley, Reading, Mass., 1968.

*Winston, Wayne and Albright, Christian. Practical Management Science, 2nd Ed.: Duxbury Thomson Learning, Pacific Grove, CA, 2000.

Distribution Fitting

If you're interested in finding out more about distribution fitting, consult any of these books:

- * Groebner, David F. and Shannon, Patrick W. *Business Statistics: A Decision-Making Approach*, 4th ed.: Macmillan Publishing Company, New York, NY, 1993.
- * Law, Averill M. and Kelton, David. *Simulation Modeling and Analysis*, 2nd ed.: McGraw-Hill, New York, NY, 1991.
- * Walpole, Ronald E. and Myers, Raymond H. *Probability and Statistics for Engineers and Scientists*, 5th ed.: Macmillan Publishing Company, New York, NY, 1993.

Distribution Functions

To learn more about the distribution functions used by @RISK's BestFit distribution fitting software, refer to the following book:

- * Evans, Merran, Nicholas Hastings and Brian Peacock. *Statistical Distributions*, 2nd ed: John Wiley & Sons, Inc, New York, NY, 1993.

Technical References to Simulation and Monte Carlo Techniques

If you would like a more in depth examination of simulation, sampling techniques and statistical theory, the following books may be useful:

- Iman, R.L., Conover, W.J. "A Distribution-Free Approach To Inducing Rank Correlation Among Input Variables": *Commun. Statist.-Simula. Computa.*(1982) 11(3), 311-334
- * Law, A.M. and Kelton, W.D. *Simulation Modeling and Analysis*: McGraw-Hill, New York, NY, 1991,1982, 2000.
- *Oakshott, Les. *Business Modeling and Simulation*: Pitman Publishing, London, 1997.
- *Ragsdale, Cliff T. *Spreadsheet Modeling and Decision Analysis*: ITP Thomson Learning, 1998.
- Rubinstein, R.Y. *Simulation and the Monte Carlo Method*: John Wiley and Sons, New York, NY, 1981.
- *Vose, David. *Quantitative Risk Analysis*: John Wiley and Sons, New York, NY, 2000.

Technical References to Latin Hypercube Sampling Techniques

If you are interested in the relatively new technique of Latin Hypercube sampling, the following sources might be helpful:

Iman, R.L., Davenport, J.M., and Zeigler, D.K. "Latin Hypercube Sampling (A Program Users Guide)": Technical Report SAND79-1473, Sandia Laboratories, Albuquerque (1980).

Iman, R.L. and Conover, W.J. "Risk Methodology for Geologic Disposal of Radioactive Waste: A Distribution - Free Approach to Inducing Correlations Among Input Variables for Simulation Studies": Technical Report NUREG CR 0390, Sandia Laboratories, Albuquerque (1980).

McKay, M.D, Conover, W.J., and Beckman, R.J. "A Comparison of Three Methods for Selecting Values of Input Variables in the Analysis of Output from a Computer Code": *Technometrics* (1979) 211, 239-245.

Startzman, R.A. and Wattenbarger, R.A. "An Improved Computation Procedure for Risk Analysis Problems With Unusual Probability Functions": SPE Hydrocarbon Economics and Evaluation Symposium Proceedings, Dallas (1985).

Examples and Case Studies Using Risk Analysis

If you would like to examine case studies showing the use of Risk Analysis in real life situations, see the following:

Hertz, D.B. and Thomas, H. Practical Risk Analysis - An Approach Through Case Histories: John Wiley and Sons, New York, NY, 1984.

* Murtha, James A. Decisions Involving Uncertainty, An @RISK Tutorial for the Petroleum Industry: James A. Murtha, Houston, Texas, 1993.

*Nersesian, Roy L. @RISK Bank Credit: Roy L. Nersesian, 1998.

Newendorp, P.D. Decision Analysis for Petroleum Exploration: Petroleum Publishing Company, Tulsa, Okla., 1975.

Pouliquen, L.Y. "Risk Analysis in Project Appraisal": World Bank Staff Occasional Papers Number Eleven. John Hopkins Press, Baltimore, MD, 1970.

* Trippi, Robert R. and Truban, Efraim. Neural Networks: In Finance and Investing: Probus Publishing Co., 1993.

*Winston, Wayne. Financial Models Using Simulation and Optimization: Palisade Corporation, 1998.

*Winston, Wayne and Albright, Christian. Practical Management Science: ITP Thomson Learning, 1997.

*Winston, Wayne. Spreadsheet Modeling: ITP Thomson Learning, 1996.

**** These titles can be purchased through Palisade Corporation. Call (800-432-7475 or 607-277-8000), fax (607-277-8001), or write to order or request further information on these and other titles relevant to risk analysis. The Palisade Technical Sales Department can also be reached by e-mail at sales@palisade.com or on the World Wide Web at <http://www.palisade.com>.***

Index

A

About Command.....	324, 380
Add Output Command.....	184
Add-In, @RISK.....	43, 173
Toolbar	163
Unloading	248, 328
Advanced Sensitivity Analysis Command	229
Alternate Parameters.....	<i>See</i> Parameters, Alternate
Anderson-Darling (A-D) Statistic.....	148, 283
Artist Window Command.....	256
Authorization	7, 323, 379
Authorization Command	323, 379
Auto-Stop	79, 193

B

BestFit	37, 129, 461
---------------	--------------

C

Cascade Command	321, 377
Check Matrix Consistency Command	273
Chi-Squared	
Binning	296
Statistic	147, 283
Circular References	191
Clear Command.....	249
Clear Curve Command	316
Collect Distribution Samples.....	196
Compatibility	13
Convergence Monitor	78, 200, 354
Copy Command.....	249, 316, 329
Correlate Distributions Command.....	266
Correlation	75, 105
Adding	266, 279
Checking Matrix Consistency.....	273

Coefficients.....	268
Deleting	271
Instances, Multiple.....	275, 426
Menu	273
Rank Order.....	270, 346, 428
Window	258, 278
Correlation Window Command.....	258
Create Distribution Command	317
Create New Instance Command	276
Critical Values	149
Cumulative Descending Percentiles . <i>See</i> Percentiles, Cumulative Descending	
Cut Command.....	249

D

Data Command	344
DecisionTools	
Suite	8, 461
Toolbar.....	8, 172
Define Chi-Sq Binning Command.....	296
Define Distribution Command.....	177, 263
Define Distribution Window	40, 61, 70
Entering Excel References.....	55
Linking to Fits.....	152, 182
Showing	177
Delete Correlation Matrix Command	271
Delete Instance Command	277
Delete Selected Row/Column(s) Command	274
Delete Tab Command	250, 331
Delimiter Defaults Command.....	314, 375
Delimiters	<i>See</i> Graphs, Delimiters
Detach Selected Input(s) Command	274
Detailed Statistics Command.....	342
Distribution	
Drawing	315
Functions	60, 381, 490
Generating Input Data from.....	302
Palette	55
Shifting	432
Truncating.....	178, 433
Distribution Window Command.....	257
Distributions	
Palette	178

E

Example Models	91–125, 491
----------------------	-------------

CLAIMS.XLS.....	101
CORRMAT.XLS	105
DEP.XLS	105
DISCRETE.XLS.....	99
ERROR.XLS	103
HIPPO.XLS	109
NCAA.XLS	123
RATE.XLS	95
SENSIM.XLS	107
VAR.XLS	119
VARIABLE.XLS	97
Excel	
Graphs.....	<i>See</i> Graphs, Excel Format
Hiding on Start of Simulation.....	193
Macros	197
Reports.....	<i>See</i> Reports, Excel
Showing	321, 377
Exit Command.....	176, 248, 328

F

Fill Down Command	329
Fill Right Command	330
Filters	
Input Data	133, 301
Result.....	83, 355
Find Outputs and Inputs Command	271
Fit Command	186, 357
Fit Curve Command	318
Fit Results Window Command.....	254
Fit Summary Window Command	255
Fit Tab Command	253
Fitting	71–73, 127–52, 490
Algorithms	139
Chi-Squared Binning	296
Continuous Distributions	135
Cumulative Data	132
Density Data	132
Discrete Distributions	135
Domain Limits	136, 294
Estimated Parameters.....	135, 293
from Artist Curve.....	318
Goodness-of-Fit Tests.....	143, 146
Importing Data.....	133
Input Data	131, 299
Linking to Excel	305
Predefined Distributions	135, 295
Sample Data.....	131

Selecting Distributions to Fit	135, 293
Simulation Results	357
Statistics	288
Format Graph Command	307, 359
Function Properties Command	264

G

Generate Data Command	302
Goal Seek	50, 209–16
Goal Seek Command	211
Goodness-of-Fit Statistics	288
Graph Command	335
Graph in Excel Command	314, 375
Graphs	84–86
Box-Whisker Plot	225
Copying	249, 329
Creating	335
Cumulative	336
Delimiters	85, 178, 313, 314, 370, 375
Excel Format	46, 151, 314, 375
Fit Comparison Graph	143, 285
Fit Difference Graph	144, 286
Formatting	85, 307, 359
Histogram Graph	336
Overlays	85, 340, 367, 371
P-P Graph	144, 286
Printing	247, 327
Q-Q Graph	145, 287
Scaling Axes	309, 363
Summary Graph	86, 338, 362
Tornado Graph	88, 115, 337

H

Help Files	323, 379
Histograms	<i>See</i> Graphs, Histograms

I

Icons	
@RISK	163
Desktop	9
Input Data Options Command	299
Inputs	
Adding	69

Collecting Distribution Samples	196, 264, 425
Finding in Excel.....	185
Listing.....	62, 74, 187
Locking.....	264, 432
Naming	180, 188, 264, 432
Properties.....	180, 265
Removing	265
Inputs and Outputs Window Command.....	259
Insert Row/Column Command	274
INSTALL.LOG File	3
Installation Instructions	7–9
Instance Commands.....	275
Instances, Multiple.....	<i>See</i> Correlation, Instances
Iteration.....	63, 190

K

Kolmogorov-Smirnov (K-S) Statistic.....	147, 283
---	----------

L

Latin-Hypercube Sampling.....	194, 458, 491
Least Squares, Method of	141
List Outputs and Inputs Command	187

M

Macros

Running Excel Macros During Simulation.....	197
VBA Control of @RISK.....	198, 437–42

Maximum Likelihood Estimators (MLEs)	139
--	-----

Menus

Advanced Analyses Menu (@RISK Add-in).....	209
Artist Menu (Model Window)	315
Correlation Menu (Model Window)	273
Edit Menu (Model Window)	249
Edit Menu (Results Window)	329
File Menu (@RISK Add-in)	175
File Menu (Model Window)	247
File Menu (Results Window).....	327
Fitting Menu (Model Window)	281
Graph Menu (Model Window)	307
Graph Menu (Results Window).....	359
Help Menu (Model Window)	323
Help Menu (Results Window)	379
Insert Menu (Model Window)	253

Insert Menu (Results Window)	335
Model Menu (@RISK Add-in)	177
Model Menu (Model Window)	263
Options Menu (@Risk Add-in)	207
Results Menu (@RISK Add-in)	203
Results Menu (Results Window)	353
Simulate Menu (@RISK Add-in)	189
Simulation Menu (Model Window)	261
Simulation Menu (Results Window)	351
View Menu (Model Window)	251
View Menu (Results Window)	333
Window Menu (Model Window)	321
Window Menu (Results Window)	377
Model Window	39, 245, 263
Showing	188, 377
Toolbars	166
Modeling	91–125
Chance Events	99
Dependency Relationships	105
Insurance Claims	101
Interest Rates	95
NCAA Tournament	123
New Product Launch	109
Oil Wells	101
Random Trends	95
Random Walks	96
Time-Dependent Variability	97
Uncertainty Around a Fixed Trend	103
Value-At-Risk (VAR)	119
Monte-Carlo Sampling	194, 457, 490
Move or Copy Window Command	330
Multiple CPUs	193

N

New Command	175, 247, 327
-------------------	---------------

O

Open Command	175, 247, 327
Outputs	
Adding	62, 184
Finding in Excel	185
Listing	62, 74, 187
Naming	184, 188, 207, 264
Properties	264
Removing	265

P

Palisade Corporation.....	5, 462
Parameters	
Alternate	52, 181, 384
Variable	105
Paste Command	249, 329
Pause on Error	192
Percentiles	
Calculating Targets	82, 146, 292, 341, 342
Cumulative Descending.....	53, 207, 343, 386
Spreadsheet Function	439
PrecisionTree	461, 465, 475–82
Print Command.....	247, 327
Prompt For Output Names Command	207
Property Functions.....	<i>See Risk Functions, Property</i>
P-Values	149

Q

Quick Report Command	358
Quick Reports	<i>See Reports, Quick</i>

R

Real-Time Results Command.....	353
Real-Time Updating	79, 199, 353
Regression	345
Remove Functions Command.....	265
Rename Instance Command	277
Rename Tab Command	250, 331
Report Settings Command	203, 357
Reports	
Copying	249, 329
Excel	44, 46, 64, 77, 90, 203, 358
Printing	247, 327
Quick	54, 204, 358
Results Window.....	64
Settings	77, 203, 357
Template Sheet	90, 204, 389
Results Window.....	45, 81, 325
Showing.....	205, 321
Toolbars	169
Risk Functions	381
Arguments	387
Arrays	388
Finding in Excel.....	185

Limiting Search Range	390
Listing in @RISK	74, 187
Property Functions	44, 264, 384, 425–34
Removing.....	265
RISKCollect.....	196, 425
RISKCorrmat.....	271, 426
RISKCurrentIter	389, 443
RISKCurrentSim.....	389, 443
RISKData	437
RISKDepC	428
RISKDiscrete.....	99
RISKFit.....	183, 305, 430
RISKIndepC	431
RISKKurtosis	438
RISKLock	432
RISKMax	438
RISKMin	439
RISKMode	439
RISKName	432
RISKOutput	43, 184, 388, 436
RISKPercentile	439
RISKRange	440
RISKResultsGraph	44, 204, 389, 445
RISKSearchRange	390
RISKShift	432
RISKSIMTable.....	107, 191
RISKSkewness	440
RISKStdDev	440
RISKTarget	441
RISKTruncate	433
RISKVariance	441
Shifting	432
Statistic Functions.....	44, 389, 437–42
Table of.....	391–98
Truncating.....	178, 433
RISKOptimizer	37
RISKview	37, 461
Root-Mean Squared Error (RMSErr).....	148, 283
RSK Files.....	175, 176
Run Fit Command.....	281

S

Save As Command	176, 247, 327
Save Command.....	176, 247, 327
Scenario Analysis	67, 88, 115
Scenarios Command	348
Seed, Random.....	191, 195, 302

Select @RISK Functions Command	185
Sensitivities Command	345
Sensitivity Analysis	
Advanced	50, 229–44
Standard	66, 87, 345
Show Excel Window Command	321, 377
Show Expanded Toolbar Command	207
Show Model Window Command	188, 377
Show Results Window Command	205, 321
SIM Files	175
Simulation	
Multiple	107, 191, 195, 339
Settings	76, 189, 351
Starting	78, 202, 351
Stopping	79, 193
Simulation Settings Command	189, 261, 351
Smooth Curve Command	316
Sort Data Command	302
Specify Distributions to Fit Command	293
Standard Recalc	194
Start Simulation Command	202, 261, 351
Statistics	
Anderson-Darling (A-D)	148, 283
Chi-Squared	147, 283
Detailed	342
Fitting	146
Kolmogorov-Smirnov (K-S)	147, 283
Root-Mean Squared Error (RMSErr)	148, 283
Summary	341
Stress Analysis	50, 217–28
Stress Analysis Command	217
Student Version	6
Summary Statistics Command	341
System Requirements	6

T

Tab Command	335
Tabs	
Deleting	250, 331
Fit Tabs	253
Inserting	253, 335
Model Tab	250
Renaming	250, 331
Technical Support	4–6
Template Sheet	<i>See Reports, Template Sheet</i>
Tile Command	321, 377
Toolbars	

@RISK Add-in	163, 207
DecisionTools	8, 172
Expanded vs Collapsed	207
Model Window	166
Results Window	169
TopRank	461, 463, 467–73
Transform Data Command	304
True EV	195
Truncation	178, 433
Tutorial	11, 59

U

Uninstalling @RISK	8
Update Display	192
Update Linked @RISK Functions Command	305
Upgrade Information	35–55

V

VBA Control of @RISK	198, 437–42
----------------------------	-------------

W

Windows

Artist Window	256, 315
Copying	330
Data Window	344
Define Distribution Window	178, <i>See</i> Define Distribution Window
Detailed Statistics Window	342
Distribution Window	257
Fit Results Window	254, 282
Fit Summary Window	255, 291
Inputs and Outputs Window	259
List of Available	321, 377
Model Window	<i>See</i> Model Window
Moving Between Tabs	330
Results Window	<i>See</i> Results Window
Scenario Analysis Window	348
Sensitivity Analysis Window	345
Summary Statistics Window	341
Write Function to Excel Command	319

