# Sensitivity Analysis Using SensIt

## Add-In for Microsoft Excel

**Contents**

Sensit is a sensitivity analysis add-in for Microsoft Excel 5, 95, 97, 98, 2000, and 2001 for Windows and Macintosh. It was written by Mike Middleton of the University of San Francisco and Jim Smith of Duke University.

## How to Install SensIt

Here are three ways to install SensIt:

(1) Start Excel, and use Excel's File | Open command to open the SensIt.xla file from floppy or hard drive.

(2) Copy the SensIt.xla file to the Excel | Library subdirectory of your hard drive. Start Excel, and use Excel's Tools | Add-Ins command to load and unload SensIt as needed.

(3) Copy the SensIt.xla file to the Excel | Startup subdirectory of your hard drive, in which case the file will be opened every time you start Excel.

All of SensIt's functionality, including its built-in help, is a part of the SensIt.xla file. There is no separate setup file or help file.

## How to Uninstall or Delete SensIt

(A) First, use your file manager to locate SensIt.xla, and delete the file from your hard drive.

(B1) If SensIt is listed under Excel's add-in manager and the box is checked, when you start Excel you'll see "Cannot find ..." Click OK. Choose Tools | Add-Ins, uncheck the box for SensIt; you'll see "Cannot find ... Delete from list?" Click Yes.

(B2) If SensIt is listed under Excel's add-in manager and the box is not checked, start Excel and choose Tools | Add-Ins. Check the box for SensIt; you'll see "Cannot find ... Delete from list?" Click Yes.

## Overview

To run SensIt, start Excel and open the SensIt.xla file. Alternatively, install SensIt using one of the methods described above. SensIt adds a Sensitivity Analysis command to the Tools menu. The Sensitivity Analysis command has four subcommands: Plot, Spider, Tornado, and Help.

Before using the SensIt options, you must have a spreadsheet model with one or more inputs and an output. All three SensIt options make it easy for you to see how sensitive the output is to changes in the inputs.

Use SensIt's Plot option to see how your model's output depends on changes in a single input variable.

Use SensIt's Spider option to see how your model's output depends on the same percentage changes for each of the model's input variables.

Use SensIt's Tornado option to see how your model's output depends on ranges you specify for each of the model's input variables.

## Example Problem

Model Display

| | A | B | C |
|---|---|---|---|
| 1 | **Spreadsheet Model For Eagle Airlines** | | |
| 2 | | | |
| 3 | **Input Variables** | **Input Cells** | |
| 4 | Charter Price/Hour | $325 | |
| 5 | Ticket Price/Hour | $100 | |
| 6 | Hours Flown | 800 | |
| 7 | Capacity of Scheduled Flights | 50% | |
| 8 | Proportion of Chartered Flights | 0.5 | |
| 9 | Operating Cost/Hour | $245 | |
| 10 | Insurance | $20,000 | |
| 11 | | | |
| 12 | **Intermediate Calculations** | | |
| 13 | Total Revenue | $230,000 | |
| 14 | Total Cost | $216,000 | |
| 15 | | | |
| 16 | **Performance Measure** | | |
| 17 | Annual Profit | $14,000 | |
| 18 | | | |
| 19 | Adapted from Bob Clemen's textbook, | | |
| 20 | Making Hard Decisions, 2nd ed., Duxbury (1996). | | |

Model Formulas

| | A | B |
|---|---|---|
| 11 | | |
| 12 | **Intermediate Calculations** | |
| 13 | Total Revenue | =(B8*B6*B4)+((1-B8)*B6*B5*B7*5) |
| 14 | Total Cost | =(B6*B9)+B10 |
| 15 | | |
| 16 | **Performance Measure** | |
| 17 | Annual Profit | =B13-B14 |
| 18 | | |

## Plot

Use SensIt's Plot option to see how your model's output depends on changes in a single input variable.

PLOT INPUT VARIABLE

Plot Input Variable's Cells: Option: In the Label edit box, type a cell reference, or point to the cell containing a text label and click. Required: In the Cell edit box, type a cell reference, or point to the cell containing a numeric value that's an input to your model.

PLOT OUTPUT VARIABLE

Plot Output Variable's Cells: Option: In the Label edit box, type a cell reference, or point to the cell containing a text label and click. Required: In the Cell edit box, type a cell reference, or point to the cell containing a formula that's the output of your model.

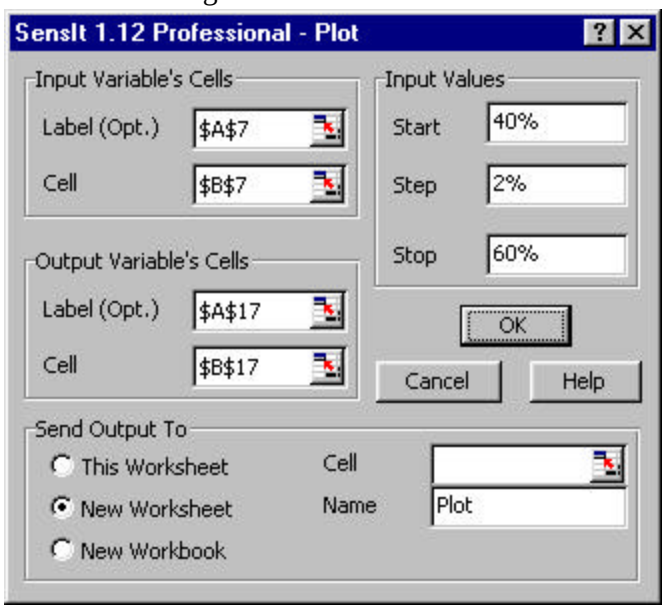
PLOT INPUT VALUES

Plot Input Values: Type numbers in the Start, Step, and Stop edit boxes to specify values to be used in the input variable's cell. Cell references are not allowed.

Send Output To: Select the destination for the output table and chart. If you send output to This Worksheet, enter a Cell reference for the top left corner of the output. Output options are not available on the Macintosh; output is always sent to a new worksheet.

Click OK: SensIt Plot uses the Start, Step, and Stop values to prepare a table of values. Each value is copied to the input variable cell, the worksheet is recalculated, and the value of the output variable cell is copied to the table. (You could do this manually using the Edit | Fill | Series and Data | Table commands.) SensIt Plot uses the input and output values to prepare an XY (Scatter) chart; optionally, the text in the label cells you identified are used as the chart's axis labels. (You could do this manually using the ChartWizard.)

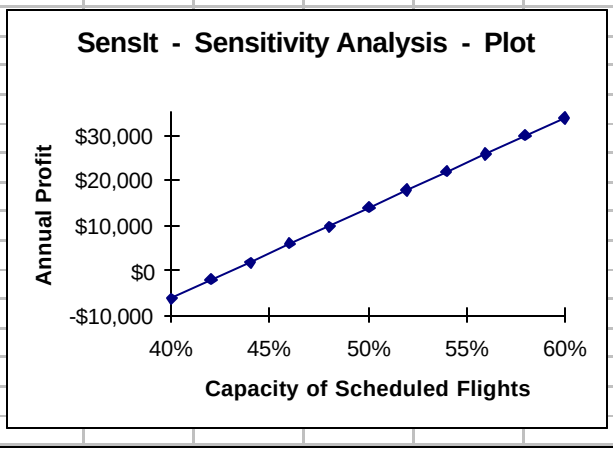
SensIt Plot Dialog Box




SensIt Plot Numerical and Chart Output

Sensitivity Analysis ...

| Input | Output |
|---|---|
| Capacity of Scheduled Flights | Annual Profit |
| 40% | -$6,000 |
| 42% | -$2,000 |
| 44% | $2,000 |
| 46% | $6,000 |
| 48% | $10,000 |
| 50% | $14,000 |
| 52% | $18,000 |
| 54% | $22,000 |
| 56% | $26,000 |
| 58% | $30,000 |
| 60% | $34,000 |



## Spider

Use SensIt's Spider option to see how your model's output depends on the same percentage changes for each of the model's input variables. Before using Spider, arrange your model input cells in adjacent cells in a single column, arrange corresponding labels in adjacent cells in a single column, and be sure your model's input cells contain base case values.

For example, if your model has five inputs, the names of the five inputs could be text in A1:A5. The input cells of your model could be numbers in B1:B5; when you change a number in one of these cells, the output of your model changes; enter base case values in the input cells B1:B5 before using Spider.

SPIDER INPUT VARIABLES

Spider Input Variables' Ranges: Labels edit box: Type a range reference, or point to the range (click and drag) containing text labels. Cells edit box: Type a range reference, or point to the range containing numeric values that are inputs to your model. Each range must be adjacent cells in a single column.

SPIDER OUTPUT VARIABLE

Spider Output Variable's Cells: Label edit box: Type a cell reference, or point to the cell containing a text label and click. Cell edit box: Type a cell reference, or point to the cell containing a formula that's the output of your model.

SPIDER INPUT CHANGES

Spider Input Changes (%): Type numbers in the Start (%), Step (%), and Stop (%) edit boxes to define the percents that will be multiplied times the current value in each input variable's cell. Cell references are not allowed.

Send Output To: Select the destination for the output table and chart. If you send output to This Worksheet, enter a Cell reference for the top left corner of the output. Output options are not available on the Macintosh; output is always sent to a new worksheet.

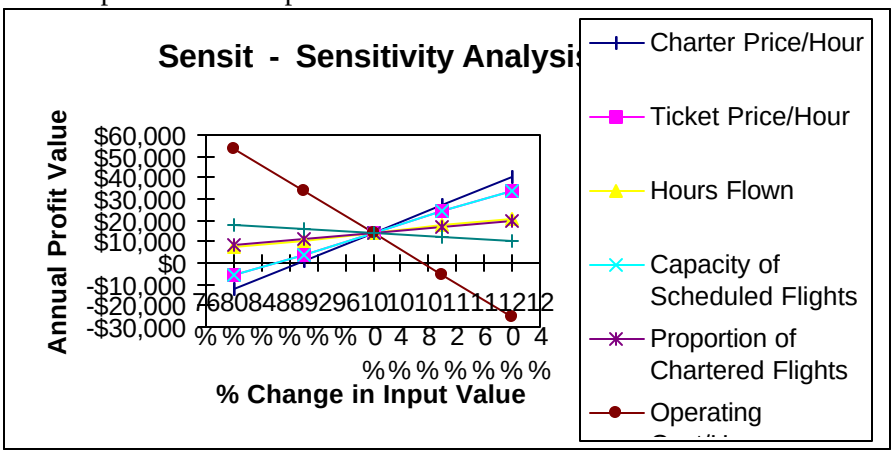
Click OK: SensIt Spider uses the Start (%), Step (%), and Stop (%) values and the original (base case) numeric value in each input variable cell to prepare a table of percentage change input values. For each input variable, all other input values are set at their base case values, each percentage change input value is copied to the input variable cell, the worksheet is recalculated, and the value of the output variable cell is copied to the table. The output variable values are also expressed as percentage change of the base case output value. SensIt Spider prepares two XY (Scatter) charts; the horizontal axis is percentage change of input variables; the vertical axis is model output value on one chart and percentage change of model output value on the other; the input variables' labels are used for chart legends.

SensIt Spider Dialog Box

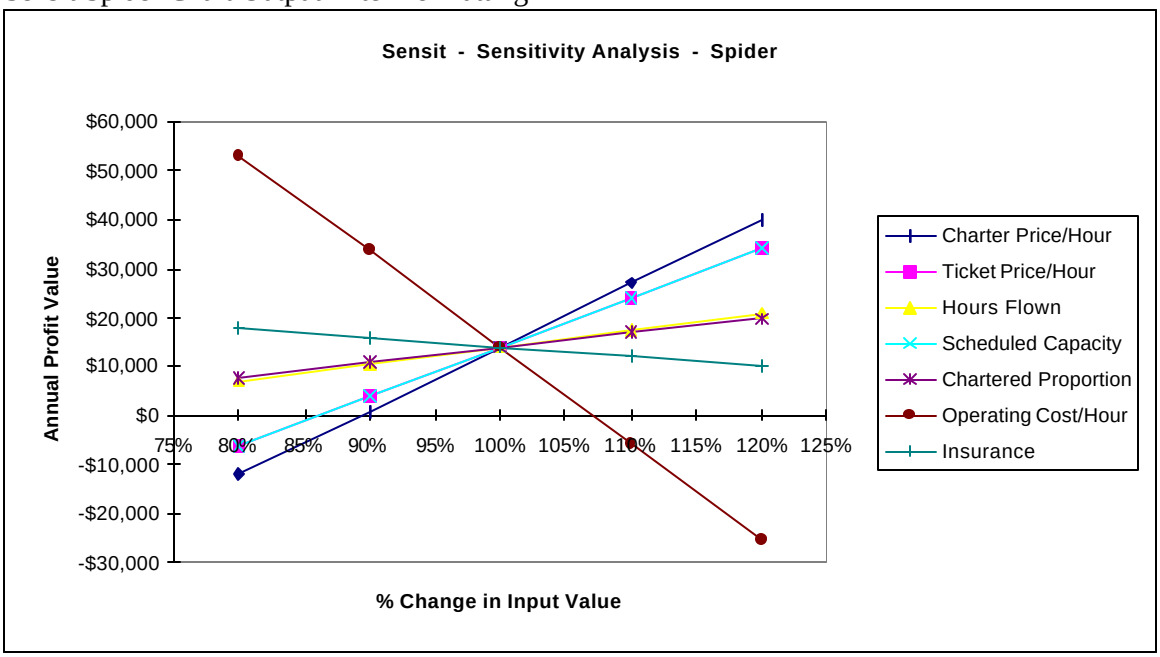

SensIt Spider Numerical Output

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | **Input Variables Values** | | | | | |
| 2 | | 80% | 90% | 100% | 110% | 120% |
| 3 | Charter Price/Hour | $260 | $293 | $325 | $358 | $390 |
| 4 | Ticket Price/Hour | $80 | $90 | $100 | $110 | $120 |
| 5 | Hours Flown | 640 | 720 | 800 | 880 | 960 |
| 6 | Capacity of Scheduled Flights | 40% | 45% | 50% | 55% | 60% |
| 7 | Proportion of Chartered Flights | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 |
| 8 | Operating Cost/Hour | $196 | $221 | $245 | $270 | $294 |
| 9 | Insurance | $16,000 | $18,000 | $20,000 | $22,000 | $24,000 |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | **Output Variable Values (Annual Profit)** | | | | | |
| 13 | | 80% | 90% | 100% | 110% | 120% |
| 14 | Charter Price/Hour | -$12,000 | $1,000 | $14,000 | $27,000 | $40,000 |
| 15 | Ticket Price/Hour | -$6,000 | $4,000 | $14,000 | $24,000 | $34,000 |
| 16 | Hours Flown | $7,200 | $10,600 | $14,000 | $17,400 | $20,800 |
| 17 | Scheduled Capacity | -$6,000 | $4,000 | $14,000 | $24,000 | $34,000 |
| 18 | Chartered Proportion | $8,000 | $11,000 | $14,000 | $17,000 | $20,000 |
| 19 | Operating Cost/Hour | $53,200 | $33,600 | $14,000 | -$5,600 | -$25,200 |
| 20 | Insurance | $18,000 | $16,000 | $14,000 | $12,000 | $10,000 |

SensIt Spider Chart Output




SensIt Spider Chart Output After Formatting



## Tornado

Use SensIt's Tornado option to see how your model's output depends on ranges you specify for each of the model's input variables. Before using Tornado, arrange your model input cells in adjacent cells in a single column, arrange corresponding labels in adjacent cells in a single column, and arrange Low, Base, and High input values for each input variable in three separate columns. Alternatively, the three columns containing input values can be worst case, likely case, and best case.

For example, if your model has five inputs, the names of the five inputs could be text in A1:A5. The input cells of your model could be numbers in B1:B5; when you change a number in one of these cells, the output of your model changes. The Low input values could be numbers in D1:D5, chosen as the minimum possible value you think each input variable could be. The Base input values could be numbers in E1:E5, chosen as the most likely value for each input; you might also have these same numbers in B1:B5 as current inputs to your model. The High input values could be numbers in F1:F5, chosen as the maximum possible value you think each input variable could be.

TORNADO INPUT VARIABLES

Tornado Input Variables' Ranges: Labels edit box: Type a range reference, or point to the range (click and drag) containing text labels. Cells edit box: Type a range reference, or point to the range containing numeric values that are inputs to your model. Each range must be adjacent cells in a single column.

TORNADO OUTPUT VARIABLE

Tornado Output Variable's Cells: Label edit box: Type a cell reference, or point to the cell containing a text label and click. Cell edit box: Type a cell reference, or point to the cell containing a formula that's the output of your model.

TORNADO INPUT VALUES

Tornado Input Values' Ranges: In the Low, Base, and High edit boxes, type a range reference, or point to the range (click and drag) containing numeric values for each of your model's inputs.

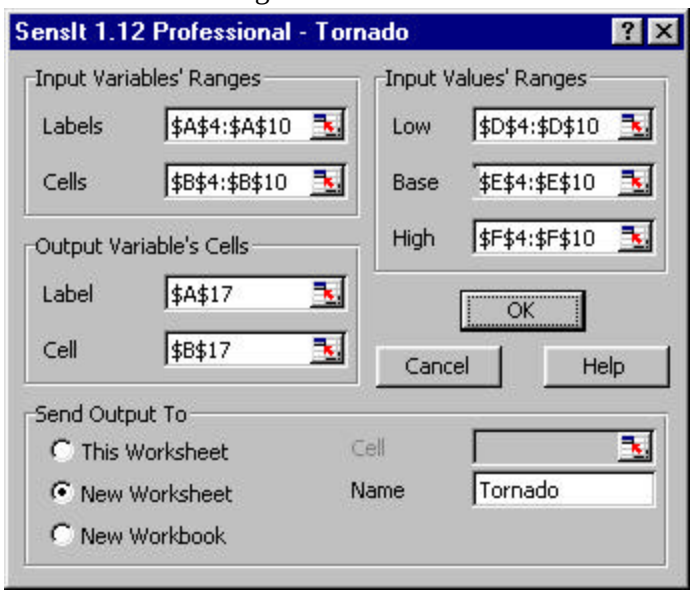
Send Output To: Select the destination for the output table and chart. If you send output to This Worksheet, enter a Cell reference for the top left corner of the output. Output options are not available on the Macintosh; output is always sent to a new worksheet.

Click OK: For each input variable, SensIt Tornado sets all other input values at their Base case values, copies the Low input value to the input variable cell, recalculates the worksheet, and copies the value of the output variable cell to the table; the steps are repeated using each High input value. For each input variable, SensIt Tornado computes the range of the output variable values, sorts the table from largest range down to smallest range, and prepares a bar chart.

Example with Lower and Upper Bounds

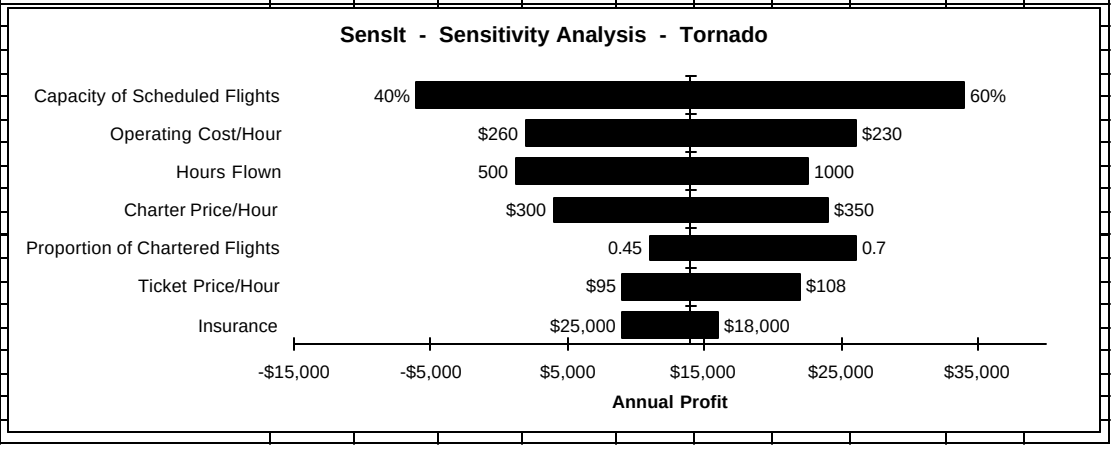
| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | **Spreadsheet Model For Eagle Airlines** | | | | | |
| 2 | | | | | | |
| 3 | **Input Variables** | **Input Cells** | | **Lower Bound** | **Base Value** | **Upper Bound** |
| 4 | Charter Price/Hour | $325 | | $300 | $325 | $350 |
| 5 | Ticket Price/Hour | $100 | | $95 | $100 | $108 |
| 6 | Hours Flown | 800 | | 500 | 800 | 1000 |
| 7 | Capacity of Scheduled Flights | 50% | | 40% | 50% | 60% |
| 8 | Proportion of Chartered Flights | 0.5 | | 0.45 | 0.5 | 0.7 |
| 9 | Operating Cost/Hour | $245 | | $230 | $245 | $260 |
| 10 | Insurance | $20,000 | | $18,000 | $20,000 | $25,000 |
| 11 | | | | | | |
| 12 | **Intermediate Calculations** | | | | | |
| 13 | Total Revenue | $230,000 | | | | |
| 14 | Total Cost | $216,000 | | | | |
| 15 | | | | | | |
| 16 | **Performance Measure** | | | | | |
| 17 | Annual Profit | $14,000 | | | | |
| 18 | | | | | | |
| 19 | Adapted from Bob Clemen's textbook, | | | | | |
| 20 | Making Hard Decisions, 2nd ed., Duxbury (1996). | | | | | |

SensIt Tornado Dialog Box



SensIt Tornado Numerical and Chart Output

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Tornado Analysis ... | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |
| 4 | | **Input Values** | | | | **Output Values (Annual Profit)** | | | | | Percent |
| 5 | Input Variable | Low | Base | High | | Low | Base | High | | Swing | Variance |
| 6 | Capacity of Scheduled Flights | 40% | 50% | 60% | | -$6,000 | $14,000 | $34,000 | | $40,000 | 46.1% |
| 7 | Operating Cost/Hour | $230 | $245 | $260 | | $26,000 | $14,000 | $2,000 | | $24,000 | 16.6% |
| 8 | Hours Flown | 500 | 800 | 1000 | | $1,250 | $14,000 | $22,500 | | $21,250 | 13.0% |
| 9 | Charter Price/Hour | $300 | $325 | $350 | | $4,000 | $14,000 | $24,000 | | $20,000 | 11.5% |
| 10 | Proportion of Chartered Flights | 0.45 | 0.5 | 0.7 | | $11,000 | $14,000 | $26,000 | | $15,000 | 6.5% |
| 11 | Ticket Price/Hour | $95 | $100 | $108 | | $9,000 | $14,000 | $22,000 | | $13,000 | 4.9% |
| 12 | Insurance | $18,000 | $20,000 | $25,000 | | $16,000 | $14,000 | $9,000 | | $7,000 | 1.4% |
| 13 | | | | | | | | | | | |
| 14 | | | | | | | | | | | |




## Tornado Tips

When defining the high and low cases for each variable, it is important to be consistent so that the "high" cases are all equally high and the "low" cases are equally low. For example, you might take all of the base case values to be estimates of the mean of the input variable, take low cases to be values such there is a 1-in-10 chance of the variable being below this amount, and take the high cases to be values such that there is a 1-in-10 chance of the variable being above this amount. Alternatively, you may specify low and high values that are the absolute lowest and highest possible values.

When you click OK, SensIt sets all of the input variables to their base-case values and records the output value. Then SensIt goes through each of the input variables one at a time, plugs the low-case value into the input cell, and records the value in the output cell. It then repeats the process for the high case. For each substitution, all input values are kept at their base-case values except for the single input value that is setn at it low or high value. SensIt then produces a spreadsheet that lists the numerical results as shown in columns F, G, and H above.

In the worksheet, the variables are sorted by their "swing" -- the absolute value of the difference between the output values in the low and high cases. "Swing" serves as a rough measure of the impact of each input variable. The rows of numerical output are sorted from highest swing at the top down to lowest swing at the bottom. Then SensIt creates a bar chart of the sorted data.

"Percent variance" is a standardized measure of impact: it squares each swing, sums them up to get a "Total Variance", and reports the percentage of the "total variance" attributed to each input variable.

In general, you should focus your modeling efforts on those variables with the greatest impact on the value measure.

If your model has input variables that are discrete or categorical, you should create multiple tornado charts using different base case values of that input variable. For example, if your model has an input variable "Government Regulation" that has possible values 0 (zero) or 1, the low and high values will be 0 and 1, but you should run one tornado chart with base case = 0 and another tornado chart with base case = 1.



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