Risk Evaluation and Management 2021/2022

@RISK handout

NOTE: you may find some differences between your version of the software and this handout; this happens either due to differences between Microsoft Office versions, either due to the use of distinct @RISK versions (e.g., in some cases "." can be ",").

Simulating Spreadsheet models using @RISK

1. Step 1

   1.1. Open Excel and @RISK enabling any macros if prompted.

1.2. The Help button is available in the Tools section of the @RISK ribbon. The @RISK Help (available at Help->Documentation->Help) is a searchable database of the user's guide and the Manual (available at Help->Documentation->Manual) is an electronic copy (PDF file) of the user's guide.

2. Step 2

   2.1. Build the soft pretzel spreadsheet as shown in Figure 1. Enter the numerical values for each assumption in the B column, and enter the formula (shown in cell C12) for *Net Contribution* in cell B12. *Net Contribution* should equal $967 when finished.

	A	B	C	D	E
1					
2					
3					
4	ASSUMPTIONS			Market proportion	Probability
5	market size	100000		16%	0,15
6	market proportion	22%		19%	0,35
7	price	0,5		25%	0,35
8	variable cost	0,1		28%	0,15
9	fixed cost	7833			
10					
11	Forecast				
12	Net contribution	967	+B5*B6*(B7-B8)-B9		

Figure 1: The Soft pretzel example

3. Step 3

   3.1. To model the input variable *Market Size* with a normal distribution:

      3.1.1. Right-click when the cursor is over cell B5 select *@RISK->Define Distributions*. A window pops up, titled *@RISK - Define Distribution: B5*, showing a set of distributions. Select Normal distribution. @RISK automatically enters the value in cell B5 (100000) as μ (mean) and as Static Value, and 10000 as σ (standard deviation) (see Figure 2). Do not

enter decimal points or thousands separators when entering numbers for the parameters. You can easily delete the current entry by double-clicking in the text box to highlight the number and typing in your number.

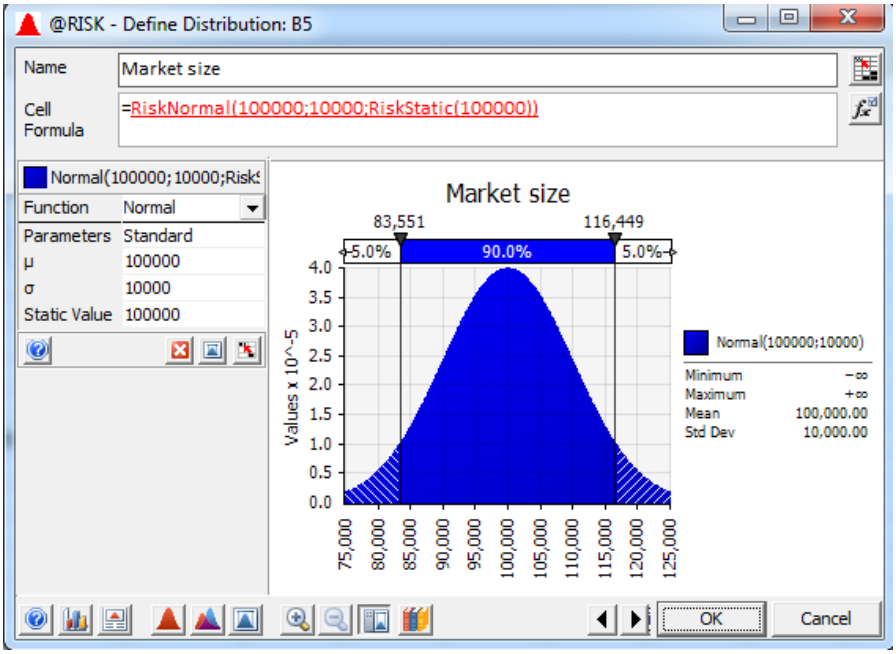


Figure 2: Defining market size (cell B5) as a normal distribution with mean 100,000 and standard deviation 10,000

3.1.2. The @RISK Define Distribution window updates the graph of the distribution as you enter the parameter values. The *Cell Formula* appears in the text box above the curve. While the formula remains red and underlined, it models the distribution being displayed in the graph.

3.1.3. Click **OK**.

3.2. Next, we model *Market Proportion* as a discrete distribution:

3.2.1. Bring up the @RISK Definition window by right-clicking when the cursor is over B6, and then selecting *Define Distributions*.

3.2.2. Select the **Discrete distribution**. You should define the parameters of the X-table and of the P-Table. Click on the rightmost button that is below the *P-Table* edit box ( ) You should choose the option to select X and P values from the *Market proportion* and *Probability* columns of the worksheet.

3.2.3. Ensure that the distribution has the adequate format, and click **OK**, and cell B6 now contains this discrete distribution.

3.3. Enter the distribution for the two remaining inputs variables by following the above steps. Specifically, set up *Variable Cost* as a **Uniform(0.08,0.12)** distribution in cell B8**,** where 0.08 is the *minimum* and 0.12 is the *maximum*; and *Fixed Cost* as a **Triang(6500,8000,9000)** distribution in B9, where 6500 is the *minimum*, 8000 is the most likely, and 9000 is the *maximum*. Be sure to click **OK** buttons to insert the distributions into cells B8 and B9.

An alternative to the *@RISK Definition Distributions* window is to use Excel's function wizard. To use it, first click the f_x button on Excel's toolbar, select the @RISK Distribution function category, then choose the particular distribution (e.g. *RiskNormal*) as shown in Figure 3.

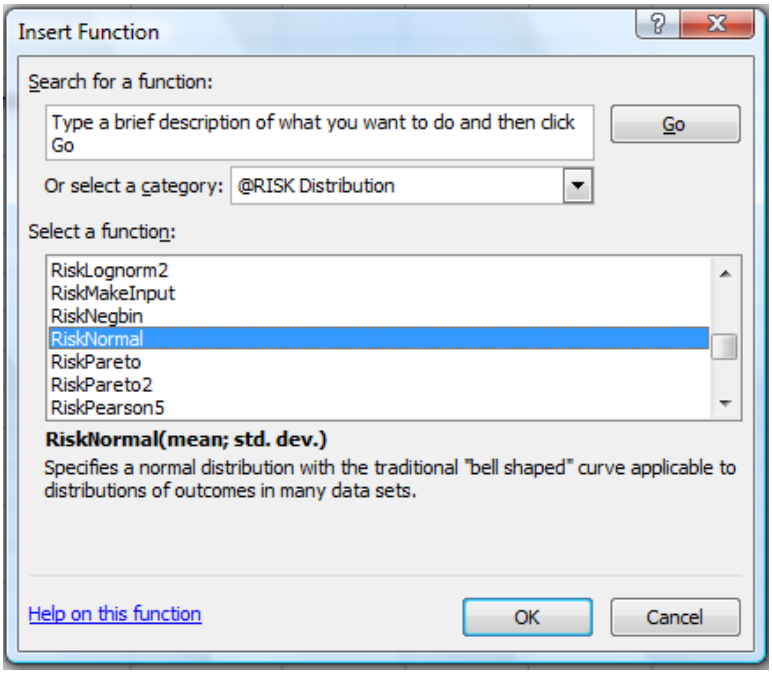


Figure 3: Excel function wizard selection window showing @RISK categories

4. Step 4
   4.1. Right-click on cell B12, choose the @RISK->*Add Output…* option.
   4.2. You should confirm on whether the output is named as "Net Contribution" and click OK. Notice that *RiskOutput()* has been added to the formula for Net Contribution in Excels' formula bar. The word "RiskOutput" identifies B12 as an output and the parentheses provide a way to name the output cells.
5. Step 5
   5.1.1. Click the *Start Simulation* button, and @RISK will simulate the model for 100 iterations. Figure 4 shows the @RISK – Output: B12 window. The numbers displayed in your window may be somewhat different because your particular run may have randomly chosen different input values, even though your model has exactly the same distributions.

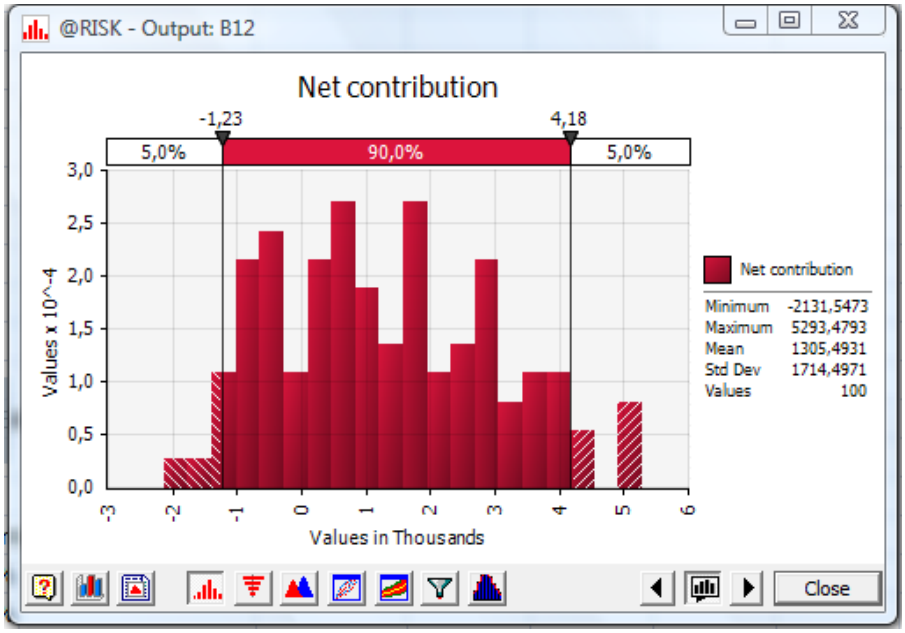


Figure 4: Histogram and simulation results for the soft pretzel model

6. Step 6

6.1. Figure 4 shows the histogram of the Net contribution. Notice that the expected Net Contribution ($1305) as well as other summary statistics, such as the standard deviation ($1714), are displayed in the right-hand side of the figure.

6.2. The two delimiters (vertical lines overlaying the graph) are markers that allow you to determine cumulative probabilities. In Figure 4 the leftmost delimiter is at the fifth percentile as shown by the 5% in the scrollbar above the curve. This delimiter is at the x value of -1230 as shown above the scrollbar. Therefore, according to the model, there is a 5% probability that the Net Contribution will be less than or equal to -1230. The 90% shown in the scrollbar indicates that there is a 90% probability that the demand will be greater than -1230 but less than 4180. The rightmost delimiter shows that there is a 5% probability that the Net Contribution will be greater than or equal to 4180.

6.3. In order to get the summary of results (Figure 5), you should click on the *Summary* button in the *Results* section of the @RISK ribbon. You can select and click over some information and analyse the results in more detail.

6.4. The two delimiters in Figure 4 can be shifted to display different cumulative probabilities. Click on a *delimiter bar* and drag it to the left or right while holding the left-button of the mouse down. Find the probably that Net Contribution will be between -2000 and 3800. (Answer: ≈ 89%).

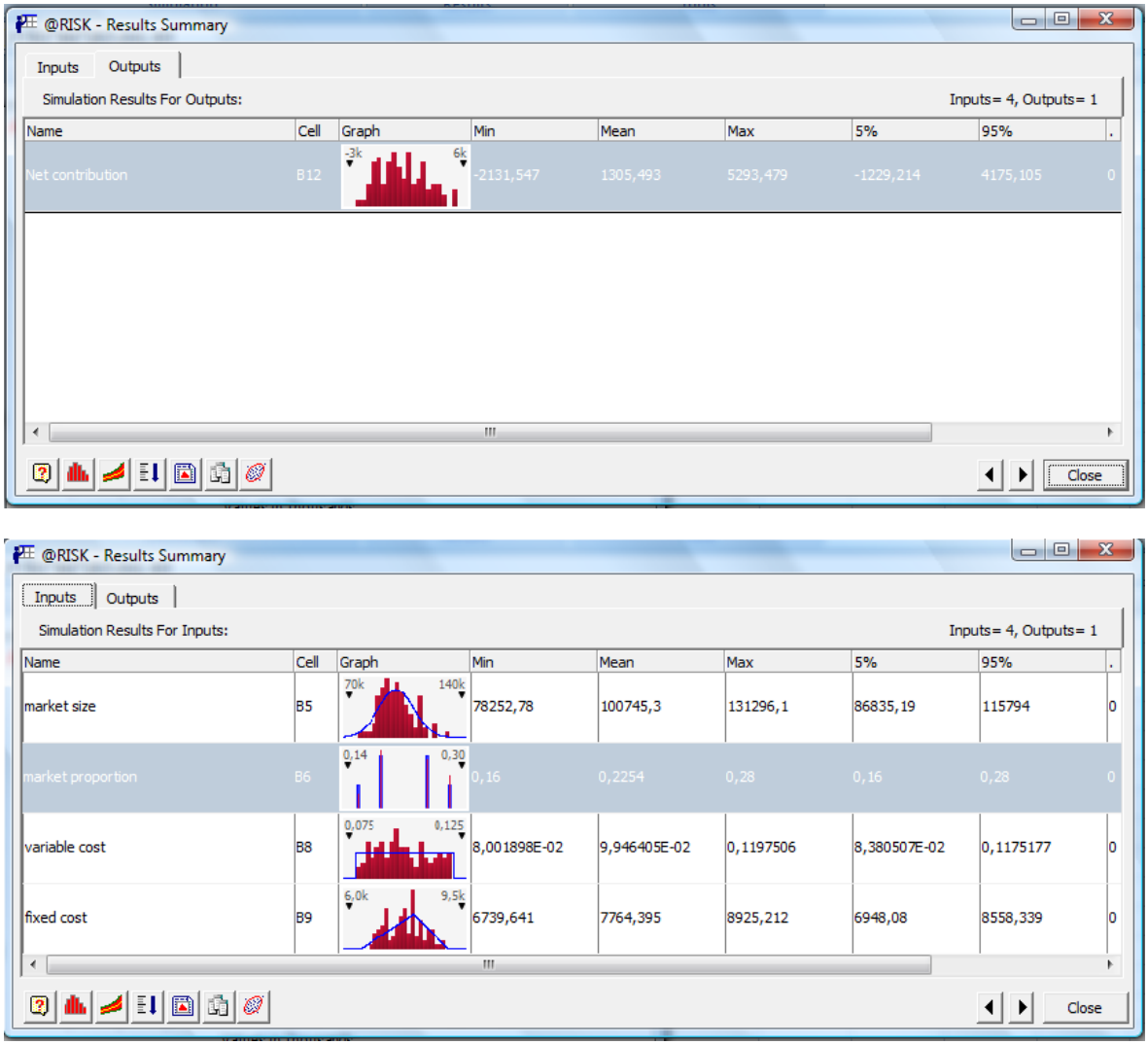


Figure 5: Summary statistics from the simulation run

6.5. Dragging the triangles to the left and right on the top of the graph also moves the bars. Find the x and y values so that there is a 20% chance that Net Contribution will be below the x value and a 20% chance that Net Contribution will be above the y value. (Answer: ≈ –$360 and $2930).

6.6. You have various options for formatting the graph. The buttons on the bottom of Figure 4 will reformat the graph to pre-specified configurations. For example, to draw the risk profile as a Cumulative Distribution function click on the button  and select *Cumulative Ascending*. Alternatively, you can access all the formatting option by right-clicking over the graph, and choosing *Graph Options…*.

7. Step 7

   7.1. In the *Simulation* area of the @RISK ribbon you can access the options related with the Simulation settings by clicking on the button  . Figure 6 shows the @RISK - *Simulation Settings* window.

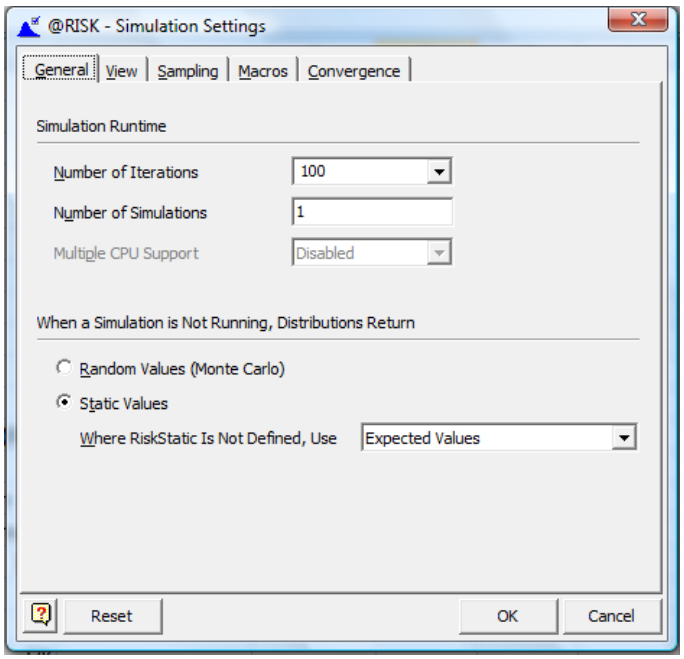


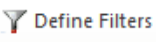
Figure 6: Some simulation settings

   7.2. To change the number of times the model is simulated, click the *Number of iterations* drop down box and type 1000.

   7.3. To have Excel display different inputs values, click the *Sampling* tab and chose *Monte Carlo* as the *Sampling Type*. Click OK.

8. Step 8

   8.1. There are four buttons at the bottom of the *Results* section of the @RISK ribbon. Click on the leftmost button to display a *Simulation Detailed Statistics* window. This window provides a complete array of statistics on all the output and input distributions.

   8.2. By clicking on the 

button or on the  button you respectively see that you can do such things as filter the data or define scenarios. @RISK's on-line help has explanations on these features.

9. Step 9

   9.1. Return to your spreadsheet and enter the prices **0.40, 0.45, 0.50, 0.55** and **0.60** in cells C15 to C19. These are the five prices we might charge for the soft pretzels.

   9.2. Highlight cell B7 and click on the 

button in the @RISK ribbon, then select Special->RiskSimTable.

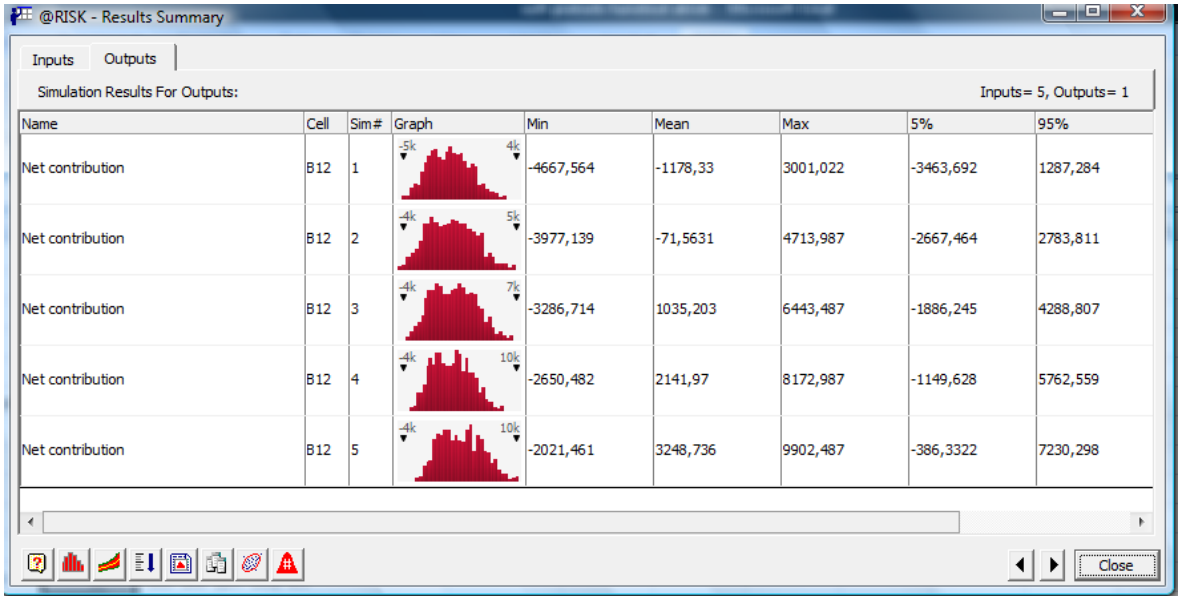
9.3. Click on the edit box *Values by sim* move the cursor to the spreadsheet, and highlight cells **C15** and **C19**. Click **OK**. This will change the value that appears for Net Contribution because "Price" is now $0.40.

9.4. We must now modify the settings so that @RISK knows to run five simulations. So, replace 1 by 5 in the *Simulation* edit box in the @RISK ribbon. @RISK will now run five separate simulations, the first with Price = 0.40, the second when Price = 0.45 and so on until Price = 0.60.

9.5. Click the *Start Simulation* button in the @RISK ribbon.

10. Step 10

10.1. Click on the *Summary* button in the *Results* section of the @RISK ribbon. Observe that the means (or expected values) increase dramatically as the price increases, as shown in Figure 7. For example, the expected Net Contribution equals $3248 when Price = $0.60, which is above the maximum Net Contribution of $3001 when Price = $0.40.



Name	Cell	Sim#	Graph	Min	Mean	Max	5%	95%
Net contribution	B12	1	-5k 4k	-4667,564	-1178,33	3001,022	-3463,692	1287,284
Net contribution	B12	2	-4k 5k	-3977,139	-71,5631	4713,987	-2667,464	2783,811
Net contribution	B12	3	-4k 7k	-3286,714	1035,203	6443,487	-1886,245	4288,807
Net contribution	B12	4	-4k 10k	-2650,482	2141,97	8172,987	-1149,628	5762,559
Net contribution	B12	5	-4k 10k	-2021,461	3248,736	9902,487	-386,3322	7230,298

Figure 7: The simulation output in the *@RISK – Results Summary* window for the five input price levels using RiskSimTable

10.2. The standard deviations are found in the *@RISK - Detailed Statistics* window (click on the button in the Results section of the @RISK ribbon). The seventh row of this window lists the standard deviation of all the input and output variables. Observe that the standard deviation increases as the prices increases. Thus, along with the higher expected value there is more uncertainty.

10.3. To graph all the five risk profiles, first display the *@RISK – Output:B12* graph, then right-click on the *Select Type of Distribution Graph to Display* ( ) button and select the option

Cumulative Ascending. Then, click on the button *Add Overlay to Graph* (), select cell B12, click OK, *Select All Simulations*, and click OK.

10.4. Figure 8 shows that the risk profile for Price = $0.60 dominates all of the others.

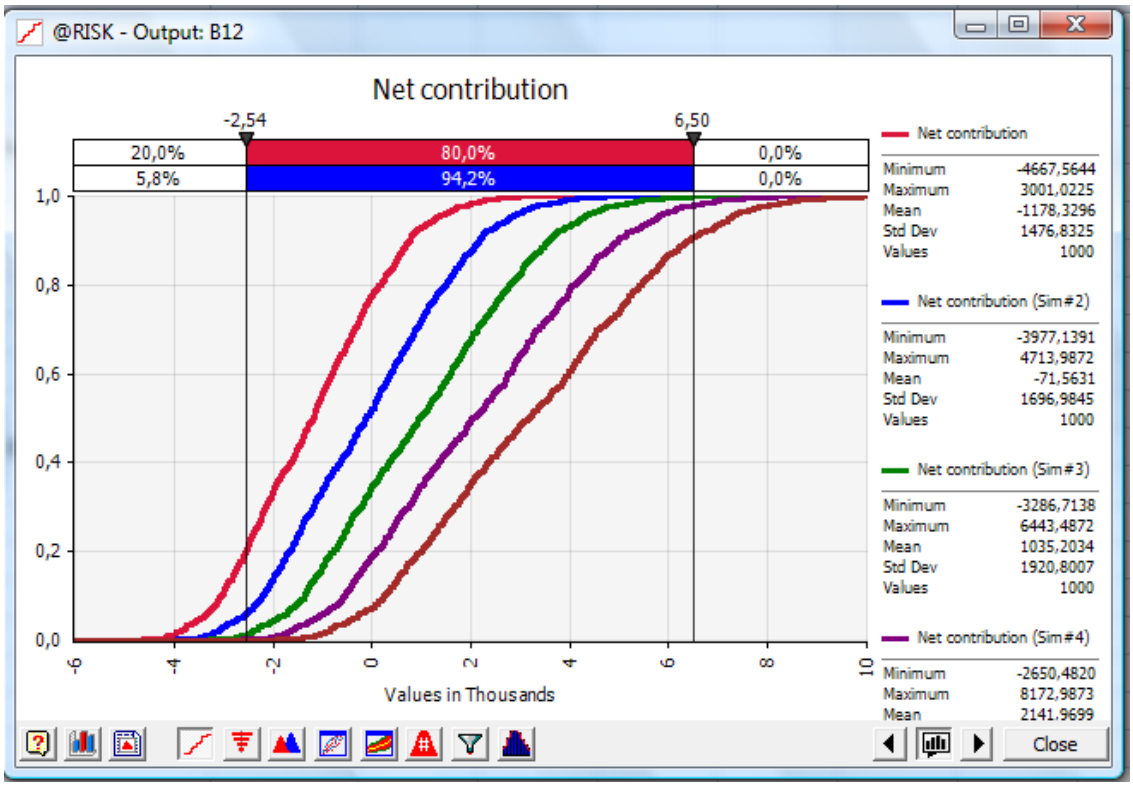


Figure 8: The five risk profiles for the five price levels showing that higher prices dominate lower price levels

11. Step 11

11.1. Close all worksheets so that @RISK clears the inputs-by-outputs table. Open a new worksheet.

11.2. Build the Soft pretzel model in Figure 9.

	A	B	C	D	E	F	G
1							
2							
3							
4	ASSUMPTIONS						
5	Market size	100000	=RiskNormal(100000;10000;RiskStatic(100000))				
6	Market proportion	22%	=RiskDiscrete(E12:E15;F12:F15;RiskStatic(0,22))				
7	Variale cost	0,1	=RiskUniform(0,08;0,12;RiskStatic(0,1))				
8	Fixed cost	7833	=RiskTriang(6500;8000;9000;RiskStatic(7833))				
9							
10			Change in		Market		
11			Market proportion		Proportion:	Probability	
12	Price levels	0,3	10%		16%	15%	
13		0,4	5%		19%	35%	
14		0,5	0%		25%	35%	
15		0,6	-5%		28%	15%	
16		0,7	-10%				
17							
18	FORECAST						
19	Net contribution 0,3	-1433	+$B$5*(C12+$B$6)*(B12-$B$7)-$B$8				
20	Net contribution 0,4	267					
21	Net contribution 0,5	967					
22	Net contribution 0,6	667					
23	Net contribution 0,7	-633					
24							

Figure 9: Spreadsheet that models dependence between prize and market proportion

11.2.1. Enter the distributions shown in C5 to C8 for the assumptions in B5 to B8.

11.2.2. Enter the price levels: $.30, $.40, $.50, $.60, $.70 in B12 to B16 and the corresponding Change in the Market Proportion: 10%, 5%, 0%, -5%, -10% in the C12 to C16.

11.2.3. Enter the five forecast formulas in cells B19 to B23. The formula for cell B19 is shown in cell C19. After entering this formula into B19, copy it down to cells B20 to B23.

11.3. Select all five of the Net Contribution equations (cells B19:B23), right-click, select the *Add Output…* option, enter Net Contribution for the name of this output range, and click OK.

11.4. Click the *Start Simulation* button in the @RISK ribbon. Figure 10 shows the *@RISK - Results Summary* window with the results of the simulations.

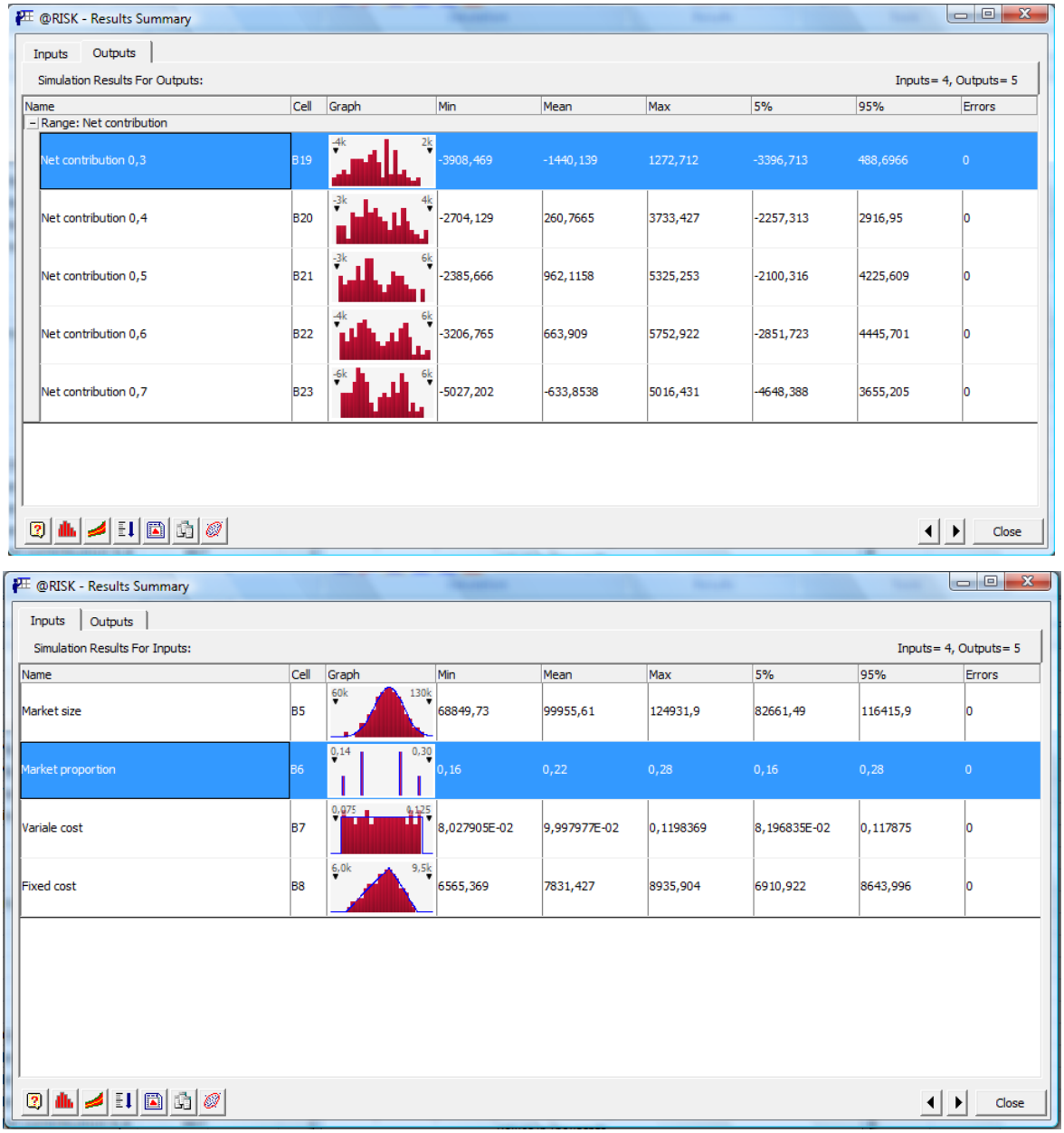


Figure 10: Summary statistics for the five different prices (B19 to B23) charged for Soft pretzels

12. Step 12

12.1. Close all worksheets, so that @RISK clears the inputs-by-outputs table, and reopen or build again the worksheet shown in Figure 1.

12.2. Modify the worksheet to match Figure 11, specifically, insert a new fourth row, and type **Market Mean** in A4 and **=RiskUniform(90000,110000)** in B4.

	A	B	C	D	E	F	G
1							
2							
3	ASSUMPTIONS						
4	market mean	100000	=RiskUniform(90000;110000;RiskStatic(100000))			Market pr	Probability
5	market size	100000	=RiskNormal(B4;10000;RiskStatic(100000))			16%	0,15
6	market proportion	22%	=RiskDiscrete(F5:F8;G5:G8;RiskStatic(0,22))			19%	0,35
7	price	0,5				25%	0,35
8	variable cost	0,1	=RiskUniform(0,08;0,12;RiskStatic(0,1))			28%	0,15
9	fixed cost	7833	=RiskTriang(6500;8000;9000;RiskStatic(7833))				
10							
11	FORECAST						
12	Net contribution	967	+B5*B6*(B7-B8)-B9				

Figure 11: Incorporating uncertainty about the mean of the distribution for market

12.2.1. Enter the distributions shown in the C column for the remaining input variables. In cell B5, be sure to indicate that the mean of the market size is given by cell B4; this is, enter =RiskNormal(B4;10000;RiskStatic(100000)) in B5.

12.3. Highlight cell **B12, right-click**, and click **Add Output…**. Name this cell *Net contribution* and click OK.

12.3.1. Click the *Start Simulation* button in the @RISK ribbon.

13. Step 13

13.1.1. Close all worksheets and construct the worksheet in Figure 12.

	A	B	C
1	**Eagle airlines model**		
2			
3			
4	ASSUMPTIONS		
5	Hours flown	779	=RiskBetaGeneral(4;2;67;1135; RiskStatic(779))
6	Capacity	50%	=RiskBeta(20;20; RiskStatic(0.5))
7	Ticket price	101.5	=RiskBetaGeneral(9;15;82;134; RiskStatic(101.5))
8	Charter price	330	
9	Charter proportion	50%	
10	Operating cost	245	=RiskNormal(245;12; RiskStatic(245))
11	Insurance	20000	
12	Price	87500	
13	Interest rate	11.50%	
14	Proportion financed	40%	
15			
16	Finance cost	4025	=B12*B13*B14
17	Revenue	227371	=B5*B8*B9+(1-B9)*B5*B6*B7*5
18	Total cost	214880	=B5*B10+B11+B16
19	Profit	12491	=B17-B18
20			
21	Estimated mean		
22	Estimated st. dev.		
23	Estimated break-even		

Figure 12: The Eagle airlines model

Note that the RiskBetaGeneral(α1, α2, min, max) is an @RISK beta distribution that is shifted from the usual interval [0, 1] to the interval [*min, max*].

13.2. Select cell B19, right-click, select *@RISK-> Add Output…*. Name this cell *Profit* and click OK.

13.3. At this point we can run a simulation that assumes independence between the input variables. Before doing this, however, let's put the expected value, standard deviation, and break-even probability of the profit distribution into the spreadsheet for later comparisons. Highlight cell B21, click on the Excel's function button (f_x button), select *@RISK Statistics* from the function category list, select the function *RiskMean*, click OK, enter B19 in the *Data source* edit box, and click OK. When the simulation finishes, cell B21 will contain the mean (i.e. the expected value) of the profit distribution.

13.4. Repeat the previous step for cells B22 and B23, but instead of *RiskMean* select RiskStdDev(B19) and RiskTarget(B19; 0). Cell B22 will contain the standard deviation of the profit distribution, and B23 will contain the break-even probability.

13.5. Click the *Start Simulation* button in the @RISK ribbon.

14. Step 14

14.1. Click the *Define Correlations* button ( ) in the @RISK ribbon.

14.2. Click the *Add inputs* button and add the input variables: *Hours Flown*, *Capacity*, *Ticket Price* and *Operating costs*.

14.3. Figure 13 shows the *@RISK – Define Correlations* window, which contains a 4×4 matrix for entering correlation values. Enter the values as shown in Figure 13. Because correlation matrices are symmetric, you need only to enter the lower diagonal values. Click OK. Select the cell D20 for the location of the matrix.

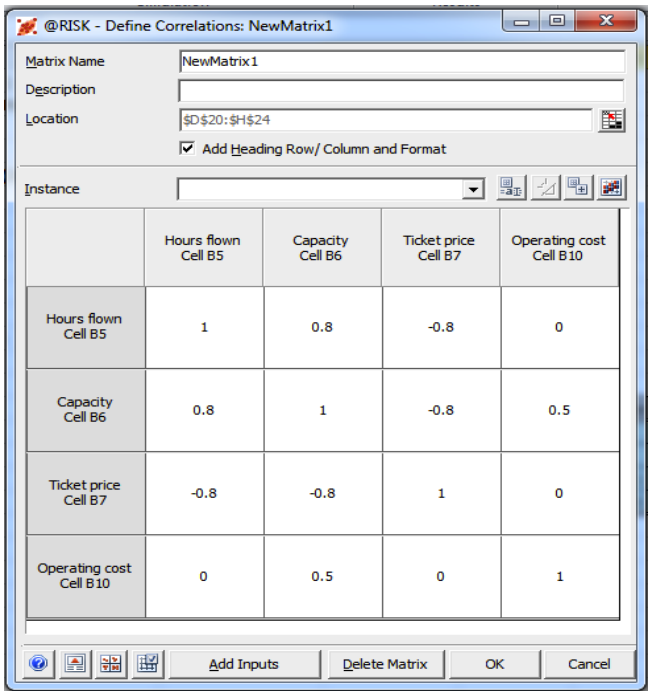


Figure 13: The correlation matrix for the four variables (Hours flows, Capacity, Ticket price, and Operating cost) in the Eagle Airlines model

14.4. The correlation matrix has been added to the spreadsheet and can be modified either in the spreadsheet or in the *@RISK - Define Correlations window*.

14.5. Click the *Start Simulation* button in the @RISK ribbon.