MAY 20, 2019

MONTE CARLO STAT ADD-IN
USER GUIDE AND FEATURES
ZAGROS ENTERPRISES LLC

https://zagrosenterprises.com/

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1. INTRODUCTION

1.1. MONTE CARLO SIMULATION

Monte Carlo simulation is a computerized mathematical technique that allows users to account for risk in quantitative analysis and decision making. The technique is used by professionals in such widely disparate fields as finance, project management, energy, manufacturing, engineering, research and development, insurance, oil & gas, transportation, and the environment.

Monte Carlo simulation furnishes the decision-maker with a range of possible outcomes and the probabilities they will occur for any choice of action. It shows the extreme possibilities the outcomes of going for broke and for the most conservative decision along with all possible consequences for middle-of-the-road decisions.

The technique was first used by scientists working on the atom bomb; it was named for Monte Carlo, the Monaco resort town renowned for its casinos. Since its introduction in World War II, Monte Carlo simulation has been used to model a variety of physical and conceptual systems.

1.2. HOW MONTE CARLO SIMULATION WORKS

Monte Carlo simulation performs risk analysis by building models of possible results by substituting a range of values—a probability distribution—for any factor that has inherent uncertainty. It then calculates results over and over, each time using a different set of random values from the probability functions. Depending upon the number of uncertainties and the ranges specified for them, a Monte Carlo simulation could involve thousands or tens of thousands of recalculations before it is complete. Monte Carlo simulation produces distributions of possible outcome values.

By using probability distributions, variables can have different probabilities of different outcomes occurring. Probability distributions are a much more realistic way of describing uncertainty in variables of a risk analysis.

Common probability distributions include:

I. NORMAL:
Or “bell curve.” The user simply defines the mean or expected value and a standard deviation to describe the variation about the mean. Values in the middle near the mean are most likely to occur. It is symmetric and describes many natural phenomena such as people’s heights. Examples of variables described by normal distributions include inflation rates and energy prices.

II. LOGNORMAL:
Values are positively skewed, not symmetric like a normal distribution. It is used to represent values that don’t go below zero but have an unlimited positive potential. Examples of variables described by lognormal distributions include real estate property values, stock prices, and oil reserves.

III. UNIFORM:
All values have an equal chance of occurring, and the user simply defines the minimum and maximum. Examples of variables that could be uniformly distributed include manufacturing costs or future sales revenues for a new product.

IV. TRIANGULAR:
The user defines the minimum, most likely, and maximum values. Values around the most likely are more likely to occur. Variables that could be described by a triangular distribution include past sales history per unit of time and inventory levels.

V. PERT:

The user defines the minimum, most likely, and maximum values, just like the triangular distribution. Values around the most likely are more likely to occur. However, values between the most likely and extremes are more likely to occur than the triangular; that is, the extremes are not as emphasized. An example of the use of a PERT distribution is to describe the duration of a task in a project management model.

VI. DISCRETE:

The user defines specific values that may occur and the likelihood of each outcome. An example might be the results of a lawsuit: 20% chance of positive verdict, 30% change of negative verdict, 40% chance of settlement, and 10% chance of mistrial. During a Monte Carlo simulation, values are sampled at random from the input probability distributions. Each set of samples is called an iteration, and the resulting outcome from that sample is recorded. Monte Carlo simulations do this hundreds or thousands of times, and the result is a probability distribution of possible outcomes. In this manner, Monte Carlo simulation provides a much more comprehensive view of what may happen. It tells you not only what could happen, but how likely it is in fact to happen.

2. WHY MONTE CARLO SIMULATION IN SHAREPOINT?

2.1. INTRODUCTION

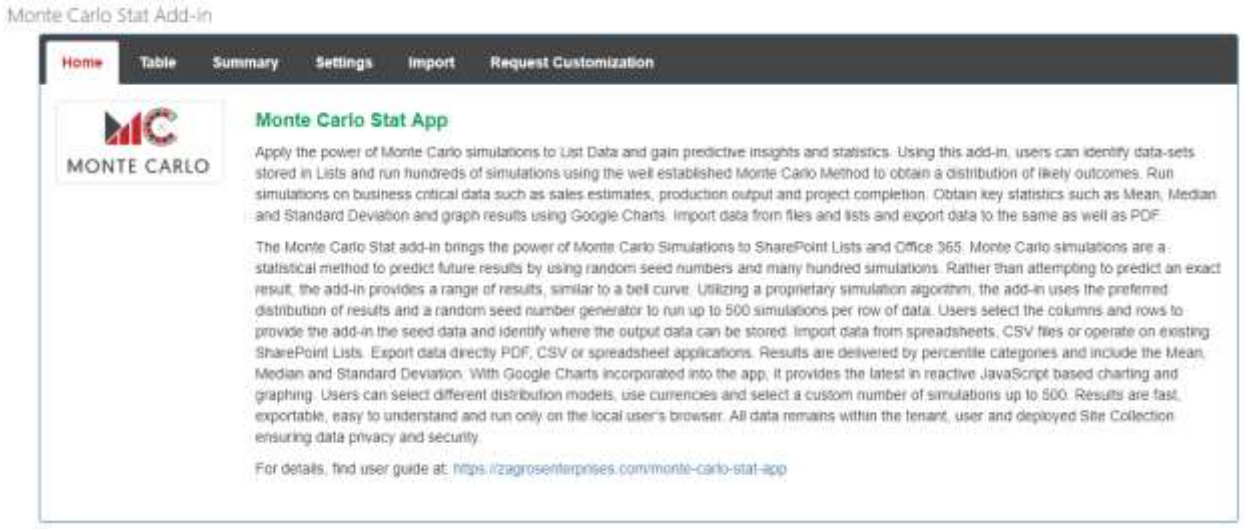
Monte Carlo simulation is commonly used to evaluate the risk and uncertainty that would affect the outcome of different decision options. Monte Carlo simulation allows the business risk analyst to incorporate the total effects of uncertainty in variables like sales volume, commodity and labor prices, interest and exchange rates, as well as the effect of distinct risk events like the cancellation of a contract or the change of a tax law. It is one of the few methods of prediction that have been shown to be statistically significant and has a long history of use in many different fields.

Monte Carlo methods in finance are often used to evaluate investments in projects at a business unit or corporate level, or to evaluate financial derivatives. They can be used to model project schedules, where simulations aggregate estimates for worst-case, best-case, and most likely durations for each task to determine outcomes for the overall project. Monte Carlo methods are also used in option pricing, default risk analysis.

3. MONTE CARLO STAT ADD-IN OVERVIEW

3.1. HOME

I. **The Home** tab shows the **Monte Carlo Stat Add-In** description and information related to the Add-In.

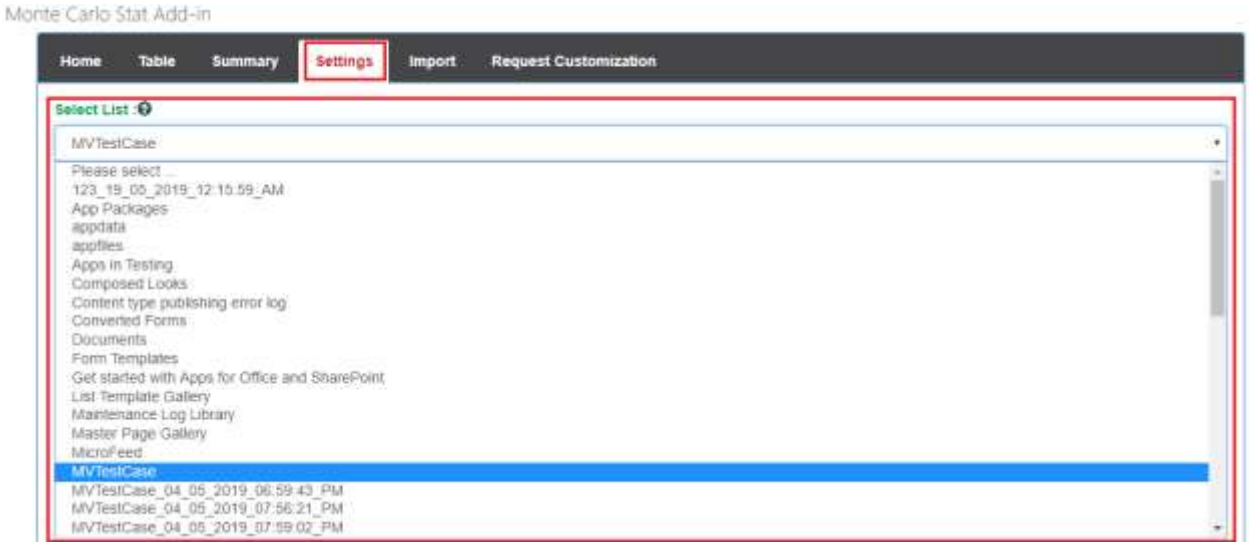


3.2. SETTINGS

3.2.1. SELECT LIST:

I. To run “Monte Carlo Simulation”, you have to select a **List** first on which you want run simulations. You can select any List on the SharePoint Site from **Settings** tab. Avoid selecting SharePoint Lists or Document Libraries. Configuration Lists, such as MicroFeed, and galleries should not be selected.

II. Click on **Select Lists** dropdown box and select list.

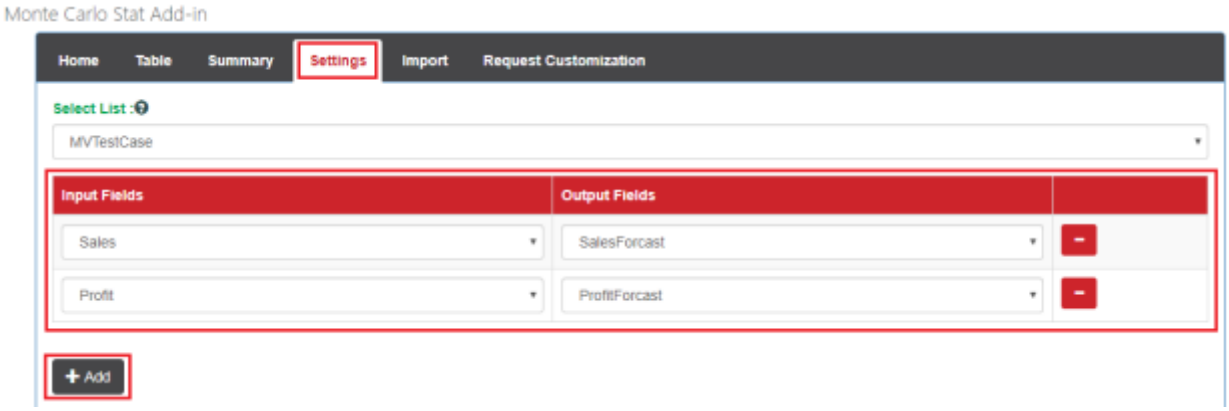


3.2.2. SELECT LIST COLUMNS:

I. After selecting a list from the dropdown menu, you must select **Columns** of the selected list on which the **Monte Carlo Algorithm** calculate values.

II. You must select columns in pairs. E.g. First select **Input Column** which will be used for Monte Carlo algorithm input values. Then Select **Output Column in** which the Add-In will store predicted values calculated by Monte Carlo Simulation based on **Input Column** values.

III. You can add or remove column pairs according to requirements.



IV. Note:

a. Users cannot select built-in list columns E.g. (Modified, Created etc.). Built-in columns will not be shown while selecting pairs of columns either.

b. Only **Number**, **Currency** and **Date** type columns can be selected and shown while selecting columns. All other data type columns will not be shown in dropdown list E.g. Text etc. Simulations cannot be run on these column types and they are hidden as a result.

3.2.3. NUMBER OF ROWS:

I. After selecting list columns pair, the user will have to input number of rows on which Monte Carlo simulation algorithm will work and predict output values. E.g. There are 500 rows in SharePoint list and you enter 10 in "No of Rows" input box then Monte Carlo Stat Add-In will only show, simulate and predict values on the first 10 rows of SharePoint List. Note there is no header row in a SharePoint

List.

3.2.4. NUMBER OF ITERATIONS:

I. Now you must input **the number of iterations** in **"No of Iteration"** input box. This value will define how many times Monte Carlo algorithm will predict a value for a input value. E.g. You enter 10 in No of Iteration input box. And there are 2 input columns, 2 output columns and total 10 rows of both columns. So for one particular value of input column there will be 10 predicted values will be generated. The average of those predicted values will save in the output column for that input. The more iterations or simulations that are run, the slower the processing will be but the more accurate the results will become. Very low values below 10 should be avoided.

No of Iterations x No of Rows x No of Columns = Total Values Generated

Example:

- No. of Iterations = 10
- Input Column 1 Value = 18
- Predicted Values = 88.277,194.404,196.524,217.382,261.904,275.245,293.843,408.836,419.161,477.387
- There are 10 values generated from Monte Carlo Algorithm. Now we will take average of these values and store it in Output Column 1.
- Output Column 1 Value = 283.296

3.2.5. SELECT DISTRIBUTION TYPE:

I. Select distribution type from dropdown box. There are two types of Distribution used in Monte Carlo Stat Add-In to predict output values.
   a. Normal Distribution.
   b. Triangular Distribution.

3.2.5.1. NORMAL DISTRIBUTION:

I. "Normal" Or "bell curve." The user simply defines the mean or expected value and a standard deviation to describe the variation about the mean. Values in the middle near the mean are most likely to occur. It is symmetric and describes many natural phenomena such as people's heights. Examples of variables described by normal distributions include inflation rates and energy prices.

II. Normal distribution uses **mean** and **standard deviation** with **random number probability** to calculate a predicted output. We calculate mean and standard deviation of each input column values and generate a random number between 0 to 1 to predict an output result.

III. For calculations we use the **NORM.INV** function. It will calculate the inverse of the normal cumulative distribution for a supplied value of x, and a given distribution mean and standard deviation. The function will calculate the probability to the left of any point in a normal distribution.

IV. Formula:

=NORM.INV (probability, mean, standard_dev)

V. The NORM.INV formula uses the following arguments:
   a. PROBABILITY:

      It is the probability corresponding to a normal distribution. It is the value at which we want to evaluate the inverse function. Probability is chance of any specific event occurring. The two extremes of this are the upper and lower level of probability (i.e. it never happens,

or it will happen). Never happens is 0 as chance and happens is 1 as probability. Hence it lies between 0 and 1.

In the **Monte Carlo Stat Add-In** we are using the **Math.Random()** function. It returns value a between 0 and 1 as discussed before.

b. MEAN:

It is the arithmetic mean. The method of calculating mean is discussed before in 4.2.

c. STANDARD DEVIATION:

It is the standard deviation of the distribution. The method of calculation standard deviation is discussed before as well in section 4.3.

3.2.5.2. TRIANGULAR DISTRIBUTION:

I. The user defines the minimum, most likely, and maximum values. Values around the most likely are more likely to occur. Variables that could be described by a triangular distribution include past sales history per unit of time and inventory levels.

II. A triangular distribution is a continuous probability distribution with a probability density function shaped like a triangle. It is defined by three values: the minimum value **a**, the maximum value **b**, and the peak value **c**.

III. The triangular distribution has a definite upper and lower limit, so as to avoid unwanted extreme values. In addition, the triangular distribution is a good model for skewed distributions. The sum of two dice is often modelled as a discrete triangular distribution with a minimum of 2, a maximum of 12 and a peak at 7.

IV. Formula:

=TRI.INV (probability, min, max, mode)

V. The TRI.INV formula uses the following arguments:

a. PROBABILITY:

It is the probability corresponding to normal distribution. It is the value at which we want to evaluate the inverse function. Probability is chance of happening of something. The two extremes of this i.e. upper and lower level of this is it never happens, or it happens. Never happens is 0 as chance and happens is 1 as chance. Hence it lies between 0 and 1.

In **Monte Carlo Stat Add-In** we are using **Math.Random()** function. It returns value between 0 and 1 as discussed before.

b. MIN:

The minimum value of Input Column.

c. MAX:

The maximum value of Input Column.

d. MODE:

The most recurring value of Input Column. Or Mean in case of non-recurring values.

3.2.6. GENERATE SIMULATION LOG FILE:

I. The purpose of the Generate Simulation Log File flag is to generate and download the detail of each Monte Carlo Algorithm simulation. Users can see how the predicted value is generated and view all of the random simulation values generated. If this flag is checked then after each simulation run, a log text file will be downloaded in the default download directory of the browser. This log file is also a valuable tool for technical support.

3.2.7. SAVE

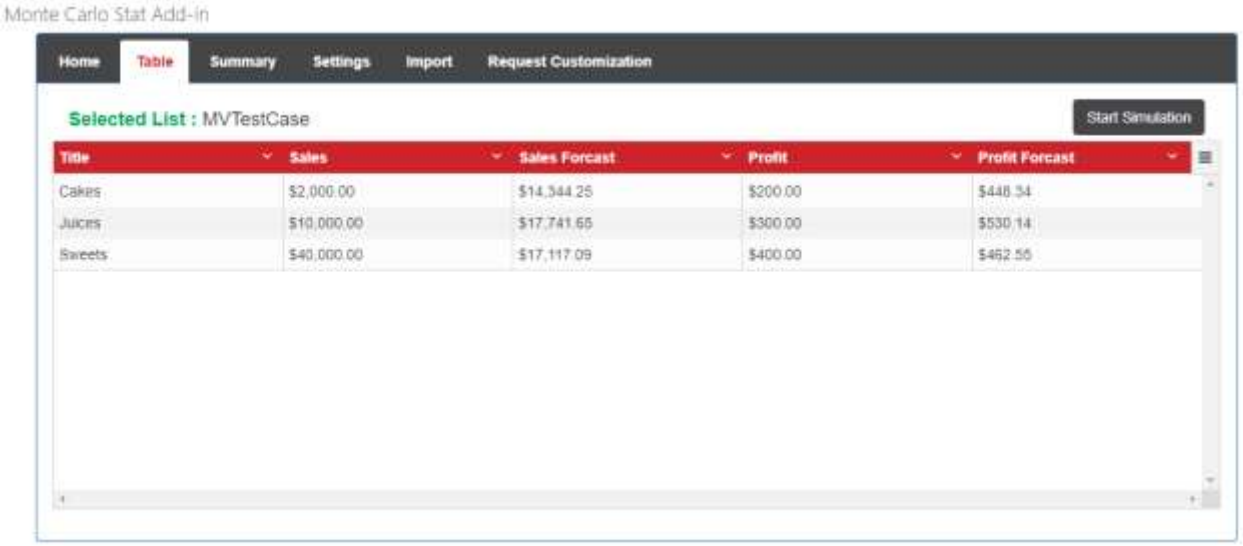
I. Press the **"Save"** button to save settings.

II. After saving the setting, the Add-In will refresh automatically and will show data according to new settings.

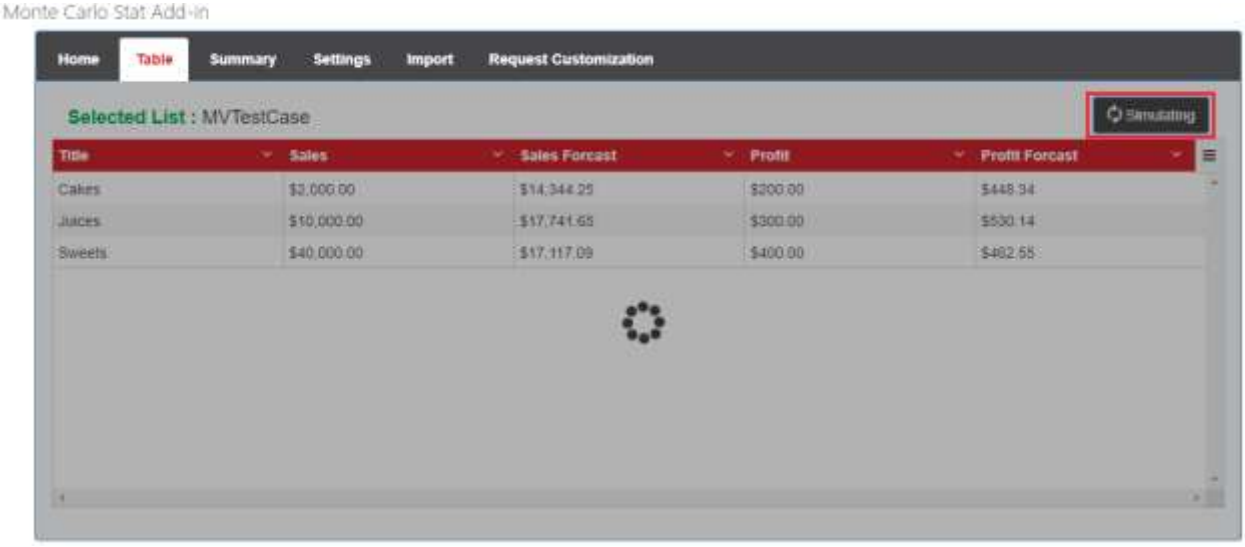
3.3. TABLE

3.3.1. TABLE AND SIMULATION

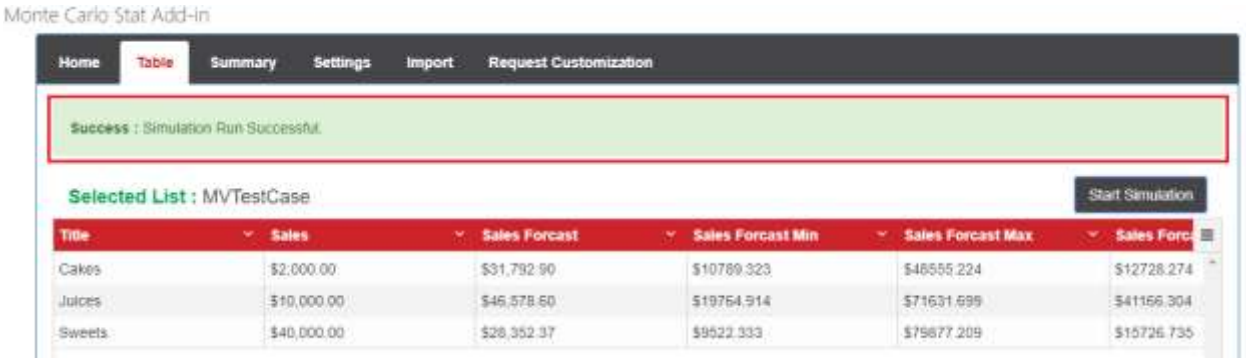
I. After saving the settings, the Add-In will redirect to the **Table** tab to display input and output column values in a responsive grid form. You will see your selected input and output columns in the **Table** tab with the **Title** column.



II. Press **Start Simulation** button to run Monte Carlo Simulation.



III. After pressing the **Start Simulation** button, the Monte Carlo algorithm will start calculating predicted values for each **Input Column** and will store predicted value in **Output Column.**



IV. After the Simulation run is successful, you will see a Success message on top of table.

V. You will notice that before running simulations there were only five columns in the table. Title, Input Column 1, Output Column 1, Input Column 2 and Output Column 2. But after, there are an additional four columns added in the table with each column pair.

VI. User's may sort and hide columns based on their preferences

VII. The Output Column's value is the average of the predicted values. As discussed in No of Iteration point. (3.2.4).

VIII. Additional columns include the Min value, Max value, 25^{th} Percentile and 75^{th} Percentile from predicted values that generated for that particular input to predict output value.

Example:

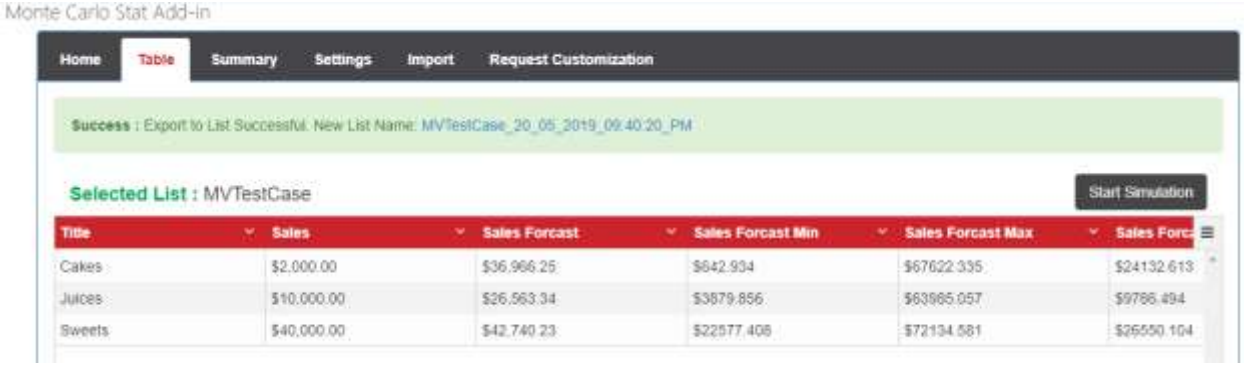
- No. of Iterations = 10
- Input Value = 18
- 10 Predicted Values:
  [138.707,146.566,161.832,165.606,206.273,212.853,232.4,273.079,289.962,487.702]
- Output Value = 231.498 (Average)
- Min Value = 138.707
- Max Value = 487.702
- **Percentile: The percentile indicates that a certain percentage falls below that percentile. For example, if you score in the 25th percentile, then 25% of test takers are below your score. The "25" is called the percentile rank.**
  a. **Finding the 25^{th} Percentile:**
  b. **Input:** [138.707,146.566,161.832,165.606,206.273,212.853,232.4,273.079,289.962,487.702]
  c. **Step 1:** Arrange the data in ascending order: 138.707, 146.566, 161.832, 165.606, 206.273, 212.853, 232.4, 273.079, 289.962, 487.702
  d. **Step 2:** Compute the position of the pth percentile (index i):
  i = (p / 100) * n), where p = 25 and n = 10
  i = (25 / 100) * 10 = 2.5
  e. **Step 3**: The index i is not an integer, round up. (i = 3) ⇒ the 25th percentile is the value in 3th position, or 161.832
  f. **Answer**: the 25th percentile is 161.832

g. There may be a minor difference in decimal values between the Monte Carlo Stat Add-In percentiles versus manually calculated percentiles due to the very precise algorithm used in the Add-In. These minor differences are inconsequential.
h. Ref: https://goodcalculators.com/percentile-calculator/

3.3.2. TABLE EXPORT

I. The Table Export feature is used to export and store results for reporting, reference or future usage. Several formats are available.
   a. Excel. (An .XLSX file will be downloaded into the default download directory.).
   b. CSV. (A .CSV (Comma Separate Value) file will be downloaded into the default download directory.PDF. (A .PDF file will be downloaded into the default download directory.
   c. SharePoint List. (A new SharePoint list will be created in the site with a default new name and exported data). A hyperlink to this list will be provided in the view and the list will automatically be stored on the same site where the Add-In is currently running.

II. There are two types of exports of data.
   a. All Data.
      - Export All Data regardless that the user may hide any column from the table view.
   b. Visible Data.
      - Export *only* visible data of the table view. If the user hides any column from the table then its data will *not be exported*.
   c. Special Case (Export to SharePoint List).
      - In the Export to SharePoint List, all data will *always* be exported to the new SharePoint List, regardless of hidden columns. The new SharePoint List name will be displayed and linked too in the success message after a successful export procedure.



3.4. SUMMARY

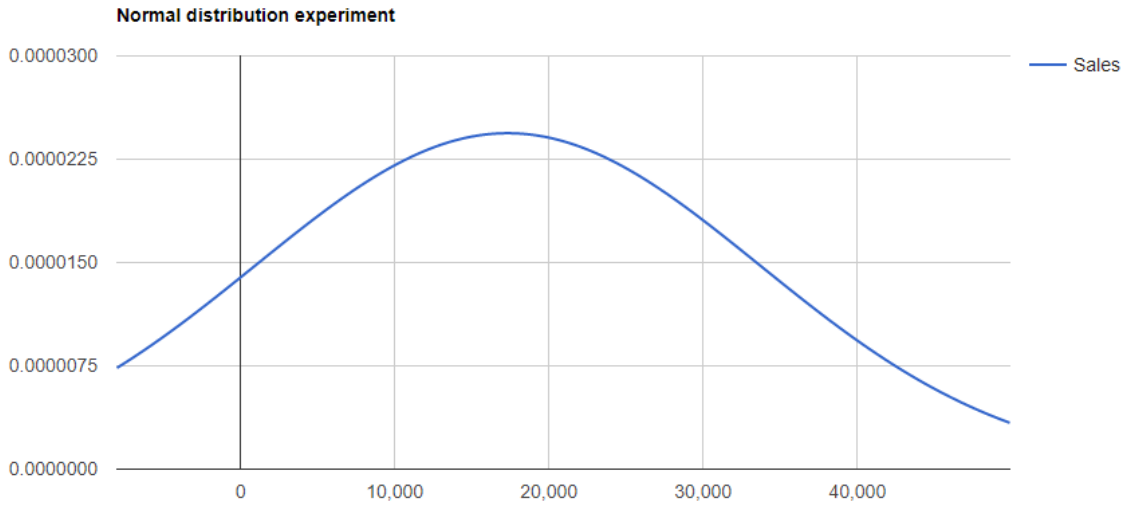
I. There is a **Summary** tab to view a summary of **Input Column** values. The Summary view includes the Mean, Median, Standard Deviation, Min, Max and Mode of input columns values. It is suitable for a quick overview of all essential information.

II. Values used in the Monte Carlo Simulations to predict **Output Column** values are displayed

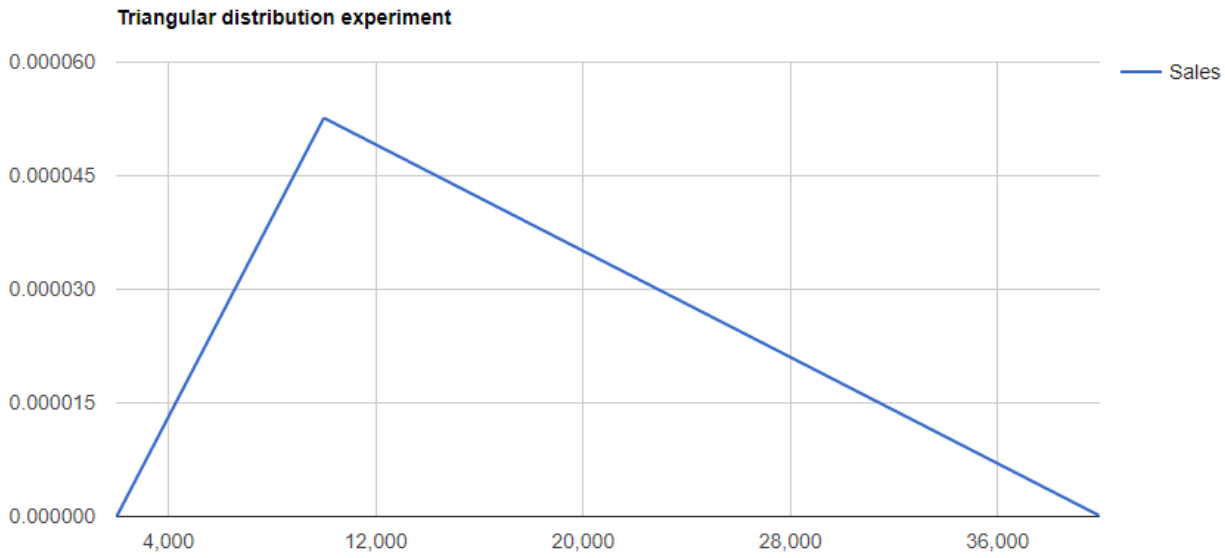
P

III. The graphing and charting feature allows users to interpret the overall trend and location of simulation results.

a. For Normal Distribution:



b. For Triangular Distribution:



3.5. DATA IMPORT

I. Users may opt to import data into a SharePoint List from Excel using the Monte Carlo Stat Add-In.

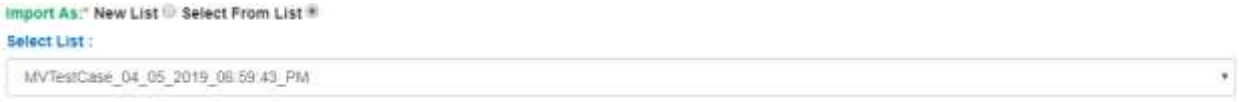
II. Select an Excel File[1] from your Local Directory.

III. Preview the Uploaded file in Grid format prior to import.

IV. Select Import to List Type:

a. New List:

b. Existing List:

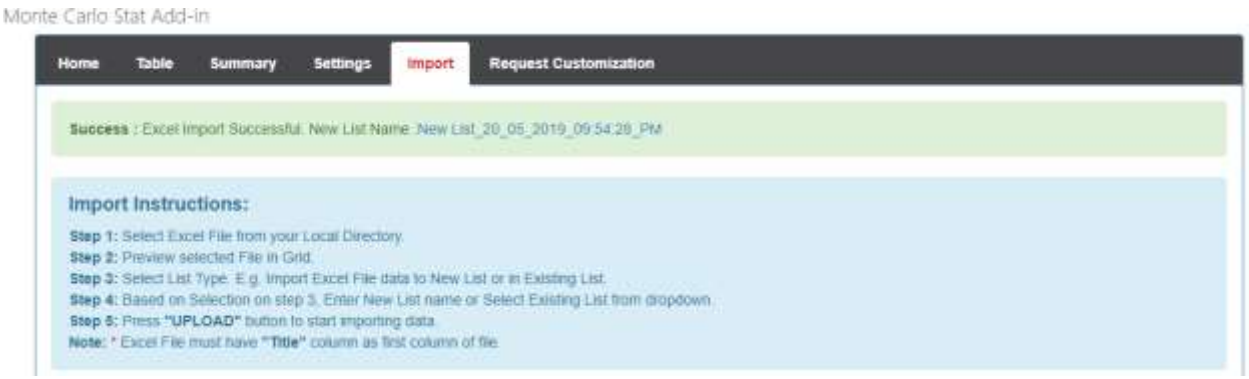


V. Press "**Upload"** to import the file.

VI. **Note:** To import the file to an existing List successfully, users must insure following thing in excel file:

a. Number of Columns must be the same both in Excel and the SharePoint selected list.
b. Sequence of Columns must be same both in Excel file and the SharePoint selected list.
c. Display name or header name in the Excel file must be the same as in the SharePoint selected list.
d. Only integer and decimal type data can be imported into a list at this time.
e. The Excel file **must** contain a text **Title** column as first column. And it is case sensitive.

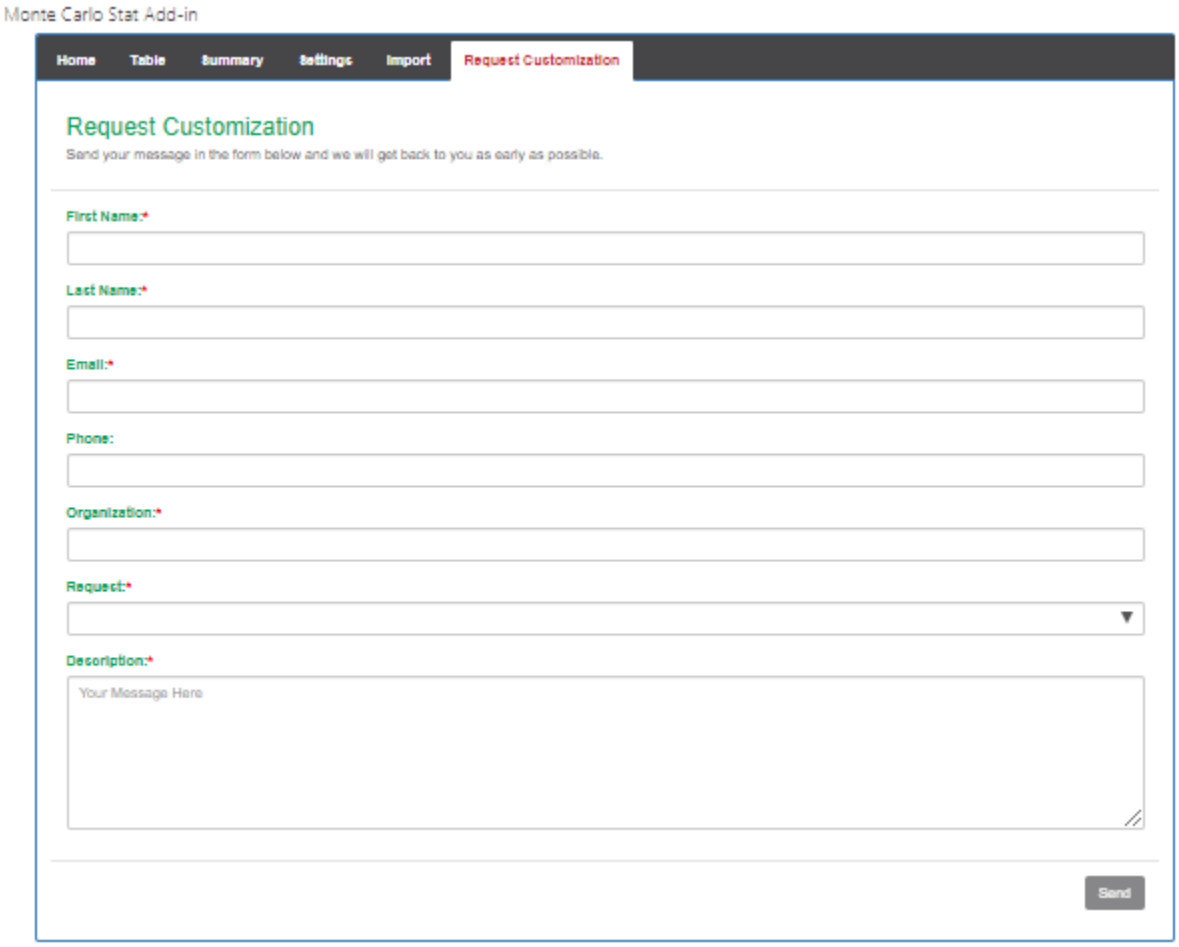
On Successful import, a Success message will be displayed on top of the Import Tab.



[1] Microsoft Excel is not required per se but the file must be in the correct format. No size limitation exists but files under 2MB are recommended. The file should also be simplified prior to import to contain only data.

3.6. REQUEST CUSTOMIZATION:

I. Please fill out the Customization Request form if you need any customization or have comments and feedback. We will contact you in a short period of time. Also, you can contact us through request customization form if you are facing any errors in the Monte Carlo Stat Add-In.



4. MONTE CARLO ALGORITHM

4.1. INTRODUCTION

The Monte Carlo Stat Add-In, heavily depends on calculations that generate Mean, Median, Standard Deviation, Min, Max, Mode and log inverse.
Suppose input columns have 3 values:

Index	Values
1	50000
2	500
3	70000

4.2. MEAN:

The mean is the average of the numbers. Simply: add up all the numbers, then divide by how many numbers there are.

So, it will be: (50000+500+ 70000)/3 = 40166.667

4.3. MEDIAN

To find the median number:

i. Put all the numbers in numerical order.
ii. If there is an odd number of values, then median is the middle value.
iii. If there is even number of values, then median will be mean of two middle values.
iv. So median will be = 50000.
v. Suppose there are 4 values, 50000, 1000,700,70000 then median will be = (1000+50000)/2 = 255000.

4.4. STANDARD DEVIATION

To calculate the standard deviation of those numbers:

i. Work out the Mean (the simple average of the numbers)
ii. Then for each number: subtract the Mean and square the result.
iii. Then work out the mean of those squared differences.
iv. Take the square root of that.
v. This is the formula for Standard Deviation:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

vi. So, means will be: (50000+500+ 70000)/3 = 40166.667

vii. Standard Deviation = Sq root (((50000-40166.667)^{2} +(500-40166.667)^{2}+(70000-40166.667)^{2}) /3
= Sq root ((96694437.889 + 1573444470.889 + 890027757.889)/3)
= Sq root(2560166666.667 /3)
= 29212.821

4.5. MIN

To find Min value:

i. Min is the minimum value from input values.
ii. So, Min will be = 500.

4.6. MAX

To find Min value:

i. Max is the maximum value from input values.
ii. So, Max will be = 70000.

4.7. MODE

To find Mode value:

i. Mode is the most recurring value from input values.
ii. Suppose there are recurring input values, 5000, 1000, 50000, 70000.
iii. So, Mode will be = 1000.
iv. If there are non-recurring input values, then we are considering media value as mode value.
v. So, Mode will be = 50000.

4.5. MONTE CARLO CALCULATION

4.5.1. NORMAL DISTRIBUTION:

Monte Carlo Simulation is used in various applications to predict or analyze data on the basis of prior knowledge. There are various techniques in which we can integrate Monte Carlo algorithm according to specific requirements. In Monte Carlo Stat Add-In we are using the well accepted **Normal Inverse Gaussian** technique to predict output values based on input values. It is *not* intended to predict the *exact* outcome, but instead to provide a range of likely values based on repeated simulations. These estimated values and ranges are highly beneficial in a wide array of tasks and fields across many industries.

Normal Inverse Gaussian uses **mean** and **standard deviation** with **random number probability** to calculate predicted output. We calculate the mean and standard deviation of each input column value and generate a random number between 0 to 1 to predict the output result.

For calculations and simulations, we are using the **NORM.INV** function. It will calculate the inverse of the normal cumulative distribution for a supplied value of **x**, and a given distribution mean and standard deviation. The function will calculate the probability to the left of any point in a normal distribution.
Formula:

=NORM.INV(probability,mean,standard_dev)

Returns the value of probability in the inverse cdf for the Normal distribution with parameters mean and std (standard deviation).

The NORM.INV formula uses the following arguments:

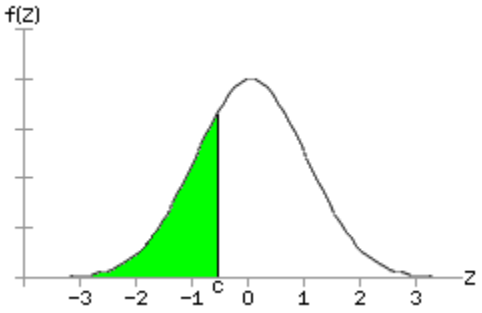
- PROBABILITY:
  It is the probability corresponding to normal distribution. It is the value at which we want to evaluate the inverse function. Probability is chance of happening of something. The two extremes of this i.e. upper and lower level of this is it never happens, or it definitely happens. Never happens is 0 as chance and definitely happens is 1 as chance. Hence it lies between 0 and 1.
  In **Monte Carlo Stat Add-In** we are using **Math.Random()** function. It returns value between 0 and 1 as discussed before.
- MEAN:
  It is the arithmetic mean of distribution. The method of calculating mean is discussed before in 4.2.
- STANDARD DEVIATION:
  It is the standard deviation of the distribution. The method of calculation standard deviation is discussed before as well in section 4.3.

4.5.1.1. EXAMPLE AND VERIFICATION

To find normal inverse:

I. Take input values.
   i. 50000
   ii. 500
   iii. 70000
II. Calculate Mean of given input values as discussed before. The mean of given input is 40166.667
III. Calculate Standard Deviation of given input values. Standard Deviation is 29212.821
IV. Now find any random number from 0 to 1 as a probability. We are using Math.Random() function to generate random numbers. For instance, we assume random number 0.2.
V. Now we have all three parameters for normal inverse function.
   i. Mean=40166.667
   ii. Standard Deviation=29212.821
   iii. Probability=0.2 (Random Number)
VI. As we discussed earlier, we are using the normal inverse distribution technique, which is based on a normal distribution curve.
   Pass these values to normal inverse function and it will return the value of left tail of Gaussian curve. For any normal distribution, the left-tail probability is the area under the curve to the left of some specific value divided by the total area under the curve. For the standard normal distribution, the total area under the curve is exactly 1. Consequently, the left-tail probability, $P(z < c)$, is just the area under the curve and to the left of c. This area is integral to the standard normal distribution function

from negative infinity to c:



$$P(z < c) = \int_{-\infty}^{c} \frac{1}{\sqrt{2\pi}} e^{-\frac{z^2}{2}} dz$$

VII. The result form the **Normal Inverse** function is 15580.5. For result verification we are using a well-known online statistical calculator to compare results.
Link: http://www.wolframalpha.com/widgets/view.jsp?id=540d8e149b5e7de92553fdd7b1093f6d

VIII. To verify result in Excel. There is also **NORM.INV()** function in Excel. Pass probability, mean and standard deviation to this function and it will return left tail value of Gaussian distribution curve.
Link: https://corporatefinanceinstitute.com/resources/excel/functions/norm-inv-function/

Results:

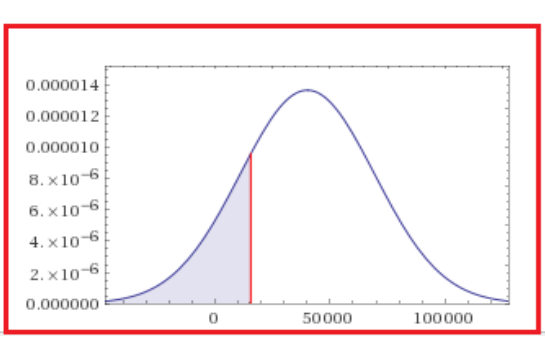
Input information:

probabilities for the normal distribution	
probability	0.2
mean	40 166.7
standard deviation	29 212.8

x-values:

left-tail	$P(z < 15\,580.5) = 0.2$
right-tail	$P(z > 64\,752.8) = 0.2$
two-tail	$P\left(\left\lvert z - \frac{2\,760\,232\,338\,469\,159}{68\,719\,476\,736}\right\rvert > 37\,437.7\right) = 0.2$
confidence level	$P\left(\left\lvert z - \frac{2\,760\,232\,338\,469\,159}{68\,719\,476\,736}\right\rvert < 7400.98\right) = 0.2$

Plot:



4.5.2. TRIANGULAR DISTRIBUTION:

I. The user defines the minimum, most likely, and maximum values. Values around the most likely are more likely to occur. Variables that could be described by a triangular distribution include past sales history per unit of time and inventory levels.

II. A triangular distribution is a continuous probability distribution with a probability density function shaped like a triangle. It is defined by three values: the minimum value a, the maximum value b, and the peak value c.

III. The triangular distribution has a definite upper and lower limit, so we avoid unwanted extreme values. In addition, the triangular distribution is a good model for skewed distributions. The sum of two dice is often modelled as a discrete triangular distribution with a minimum of 2, a maximum of 12 and a peak at 7.

IV. Formula:

=TRI.INV (probability,min, max, mode)

Returns the value of probability in the inverse cdf for the Triangular distribution with parameters min, max and mode.

V. The TRI.INV formula uses the following arguments:

e. PROBABILITY:

It is the probability corresponding to normal distribution. It is the value at which we want to evaluate the inverse function. Probability is chance of happening of something. The two extremes of this i.e. upper and lower level of this is it never happens, or it happens. Never happens is 0 as chance and happens is 1 as chance. Hence it lies between 0 and 1. In **Monte Carlo Stat Add-In** we are using **Math.Random()** function. It returns value between 0 and 1 as discussed before.

f. MIN:

The minimum value of Input Column.

g. MAX:

The maximum value of Input Column.

h. MODE:

The most recurring value of Input Column. Or Mean in case of non-recurring values.

4.5.2.1. EXAMPLE AND VERIFICATION:

To find normal inverse:

I. Take input values.
   i. 50000
   ii. 500
   iii. 70000

II. Calculate Min of given input values as discussed before. The Min of given input is 500.

III. Calculate Max of given input values as discussed before. The Max of given input is 70000.

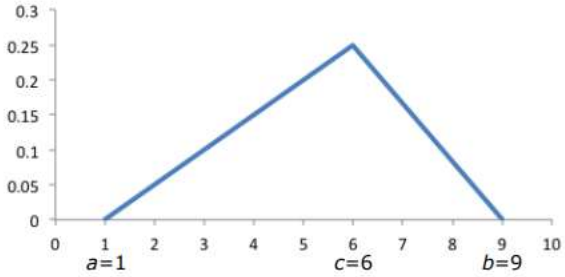
IV. Calculate Mode of given input values. As there are non-recurring values, we will use Median as Mode. That is 50000.

V. Now find any random number from 0 to 1 as a probability. We are using Math.Random() function to generate random number. For instance, we assume random number 0.2.

VI. Now we have all four parameters for normal inverse function.

i. Min=500.
ii. Max=70000.
iii. Mode = 50000.
iv. Probability = 0.2 (Random Number)

VII. All probability density functions have the property that the area under the function is 1. For the triangular distribution this property implies that the maximum value of the probability distribution function is 2/(b-a). It occurs at the peak value of c. The probability density function of a triangular distribution is zero for values below a and values above b. It is piecewise linear rising from 0 at a to 2/(b-1) at c, then dropping down to 0 at b. The graph below shows the probability density function of a triangle distribution with a=1, b=9 and c=6. The peak is at c=6 with a function value of 0.25.



VIII. The formula for the probability density function is:
Given a random variate U drawn from the uniform distribution in the interval (0, 1), then the variate:

$$X = \begin{cases} a + \sqrt{U(b-a)(c-a)} & \text{for } 0 < U < F(c) \\ b - \sqrt{(1-U)(b-a)(b-c)} & \text{for } F(c) \le U < 1 \end{cases}$$ [2]

where *F(c)=(c-a)/(b-a),* has a triangular distribution with parameters *a,b and c*. This can be obtained from the cumulative distribution function,

IX. In our example:
i. U=0.2
ii. a=1000 (Min)
iii. b=70000 (Max)
iv. c=50000 (Mode)
v. *F(c)=(c-a)/(b-a)=0.7101*

So base on condition, 0<U<F(c)

X = 1000 + SQRT (0.2 (70000 -1000) * (50000 – 1000))
= 1000 + SQRT (3381000000)
= 1000 + 26003.8458
= 27003.8458

X. To verify result, you have to make this formula in excel sheet and match the results.
Ref: https://en.wikipedia.org/wiki/Triangular_distribution

XI. Sample Excel file with default formula. Change Random number generation logic to verify result.
Ref: http://faculty.citadel.edu/betterton/BADM731/Triangular-Distribution.xls

5. DATE/TIME DATA TYPE:

5.1. DETAIL:

I. There is special user case in Monte Carlo Stat Add-In to handle the **Date/Time** datatype. This is useful for estimating task end dates
II. Date/Time type data type is very complex to handle. For the Date/Time data type the Add-In has to convert date to a Integer or Float to calculate parameters for distribution functions.
III. It is easy to calculate mean and standard deviation of Integer and Float types. There are several methods available in JavaScript that can calculate these values for Integer and Float. However, there is no method available which can find out mean and standard deviation for Date/Time type.

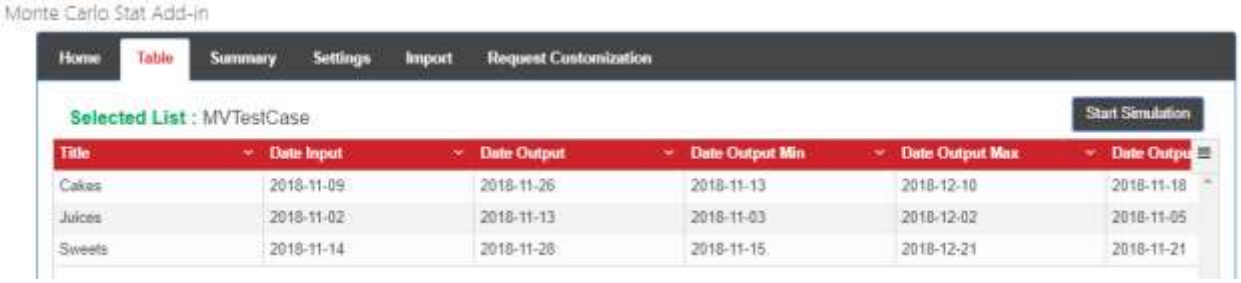
5.2. SOLUTION:

I. First step to calculate mean and standard deviation of Date/Time type column is to sort the Date/Time type column in ascending order. (Oldest date to Latest Date).
II. Then we find out difference of each date from oldest date. From this we get days value as Integer.
III. Now save days values in temporary buffer.
IV. Find out Mean from days temporary buffer as we find mean for Integer type.
V. Find out Standard Deviation from days temporary buffer.
VI. Find out Min days value.
VII. Find out Max days value.
VIII. Find out Median value.
IX. Now we have all required parameters for both Normal and Triangular distribution.
X. Generate Random variable and according to distribution type, pass required parameters to distribution function to get predicted value.
XI. But problem is that predicted value again in Integer or in Float type. The predicted value is in days form. But what we need is a predicted Date/Time value.
XII. For this we are using **Moment.js** library, Moment.js is used to add days in particular date to generate new date.
XIII. Now we have predicted value as days, and Input value for which predicted days have been calculated. By using Moment, we just simply added predicted days in input date and find out output value for that particular input value.
XIV. This is how Monte Carlo algorithm working for Date/Time type.

5.3. EXAMPLE:

I. Suppose we have three Date/Time values: 2018-11-09, 2018-11-02, 2018-11-14
II. Sort ascendingly: 2018-11-02, 2018-11-09, 2018-11-14.
III. Calculate difference (Days) = 2018-11-09 - 2018-11-02 = 7 and 2018-11-14 - 2018-11-02 = 12.
IV. Calculate Mean = 9.500.
V. Calculate Median = 9.500.
VI. Calculate Standard Deviation = 2.500
VII. Calculate Min = 7.00, Max = 12.00 and Mode = 7.00.
VIII. Now predict value for input = 2018-11-14.
IX. Random Numbers = [0.742,0.792,5.082,9.811,10.87,11.307,14.595,16.591,29.065,36.313]

X. Average Values (Mean)= 13.5168
XI. Median = 11.0885
XII. Min = 0.742
XIII. Max = 36.313
XIV. Standard Deviation = 10.92
XV. So now we just add these values as days in Input Date/Time to calculate output values.
XVI. Output Value = 2018-11-14 + Ceil (13.5168(days)) = 2018-11-28
XVII. Date Time Output Average: 2018-11-14 + Ceil (13.5168(days)) = 2018-11-28
XVIII. Date Time Output Min: 2018-11-14 + Ceil (0.742(days)) = 2018-11-15
XIX. Date Time Output Max: 2018-11-14 + Ceil (36.313(days)) = 2018-12-21



6. BROWSER COMPATIBILITY AND SUPPORT

The Monte Carlo Add-In uses advanced features that don't necessarily work with all web browsers. Outlined below are the supported browsers and versions. To request additional support, please use the Request Customization form.

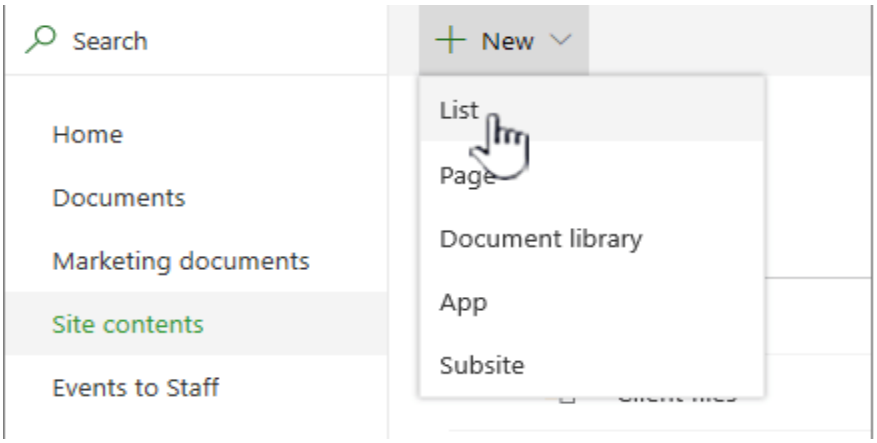
IE (<=10)	Not Supported
IE 11	Supported
Google Chrome	Supported
Firefox	Supported
Edge	Supported

7. TEST ADD-IN

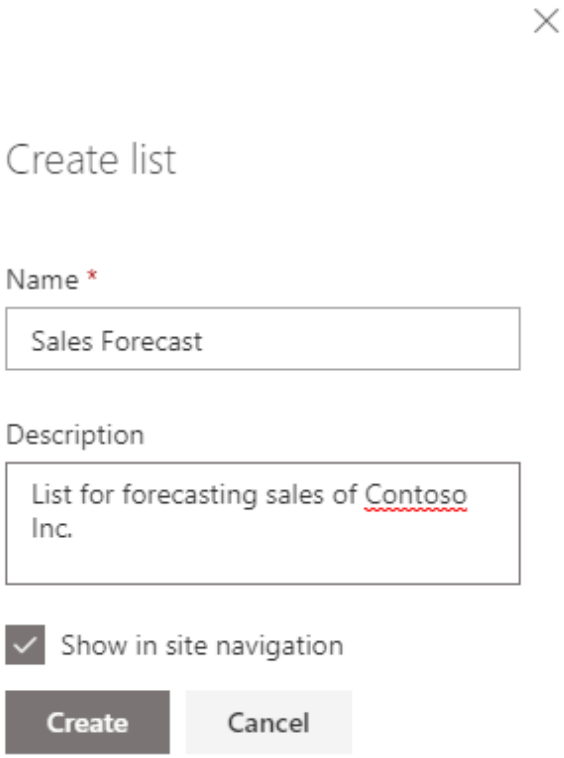
Contoso Inc, a sales and marketing company needs sales forecasting.

7.1. STEP 1 – CREATE LIST

1. Click **Settings** and then click **Site contents**.
2. Click **+ New**, and then click **List.**

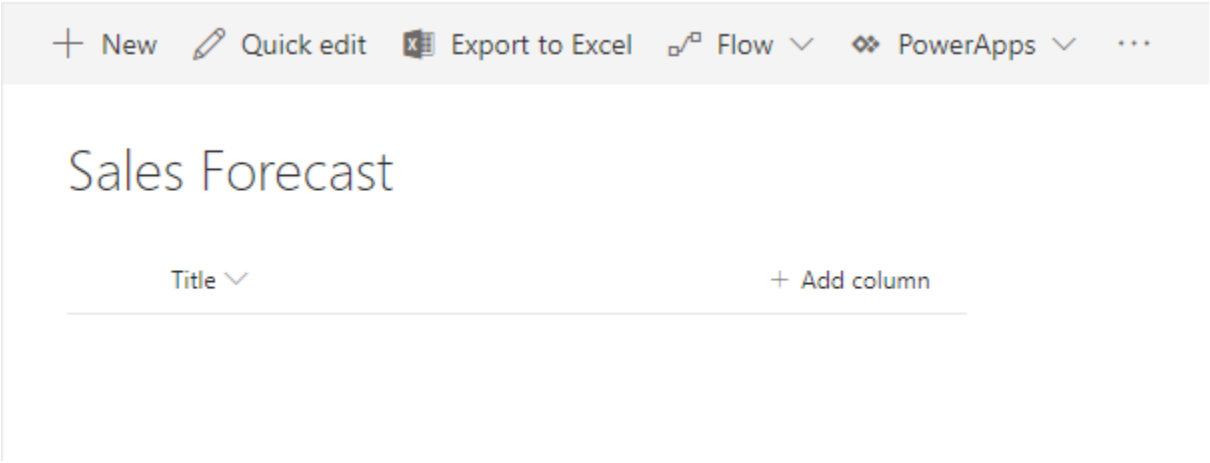


3. Type a **Name "Sales Forecast"** for the list, and optionally, type a **Description**.
   The name "Sales Forecast" will appear at the top of the list and can show in site navigation to help others find it.

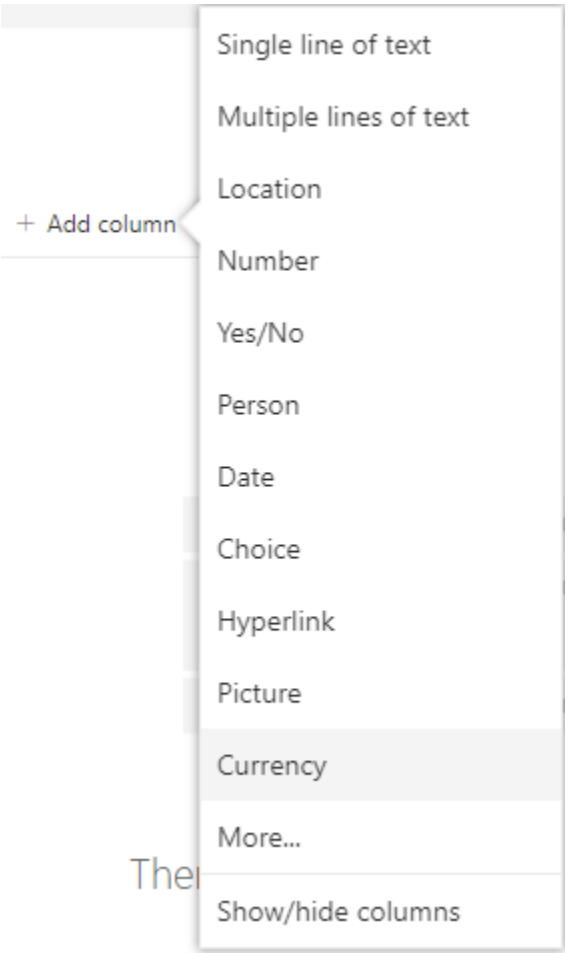


4. Click **Create.**

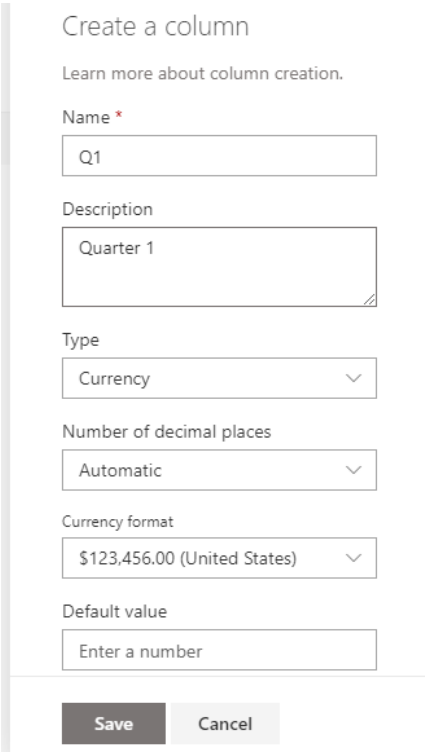
5. When your list opens, you can click **+** or **+ Add column** to add room for more types of information to the list.



6. Select **+ Add column.**
7. In the dropdown menu, choose the type of column as "**Currency**".

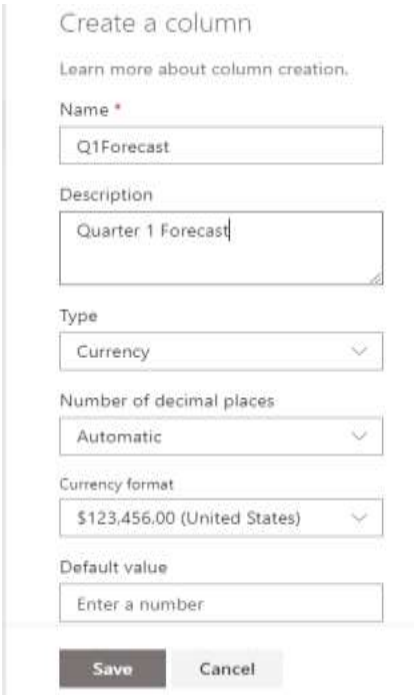


8. In the Create a column panel, type "**Q1**" or "**Quarter1**" into the **Name** field.
   Note: Remember "**Q1**" is an input column for Monte Carlo Stat Add-In. It should store input values for Monte Carlo Stat Add-In.



9. Click **Save**.

10. Repeat from **Step 6**, and In the Create a column panel, type "**Q1Forcast**" or "**Quarter1Forcast**" into the **Name** field.
    Note: Remember "**Q1Forcast**" is an output column for Monte Carlo Stat Add-In. It will store forecasted value base on "**Q1**" column values after running Monte Carlo Algorithm on **Q1** column values.
11. Click **Save**.



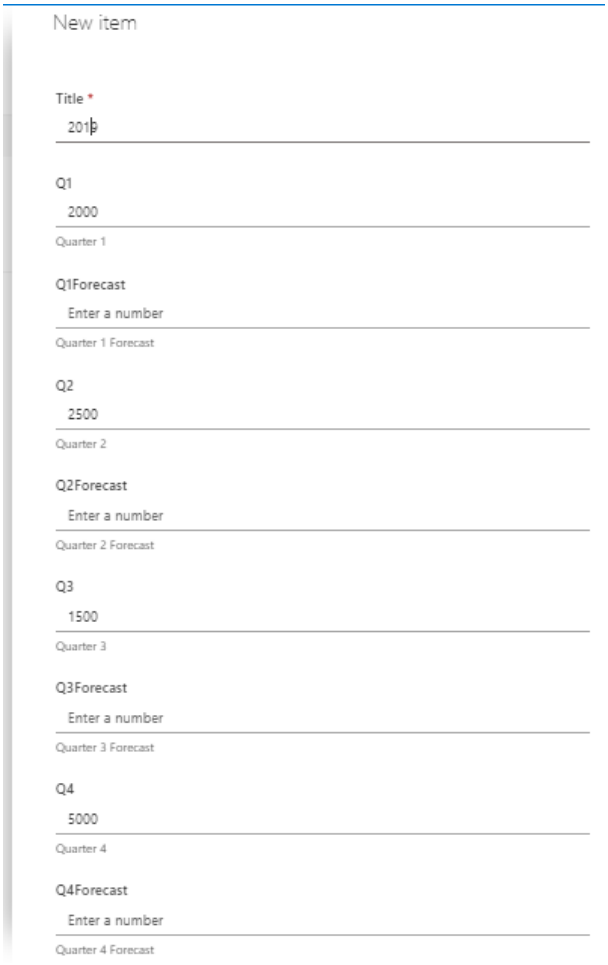
12. Repeat from **Step 6** to create columns:
    I. Q2.
    II. Q2Forecast.
    III. Q3.
    IV. Q3Forecast.
    V. Q4.

VI. Q4Forecast.

13. Now list and columns have been created. To insert data, Click +**New** button from top bar.
14. In New item panel, Type following details:
    I. **Title**: 2019
    II. **Q1**: 2000
    III. **Q1Forecast**: (left blank).
    IV. **Q2**: 2500
    V. **Q2Forecast**: (left blank).
    VI. **Q3**: 1500
    VII. **Q3Forecast**: (left blank).
    VIII. **Q4**: 5000
    IX. **Q4Forecast**: (left blank).

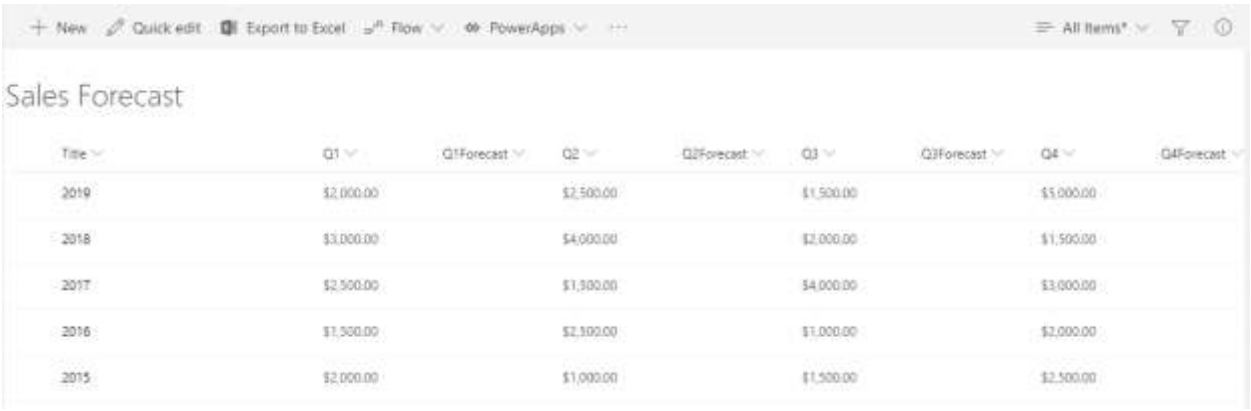
    Note: Columns **Q1Forecast, Q1Forecast, Q1Forecast** and **Q1Forecast** will update automatically after running Monte Carlo Stat Add-In algorithm on **Q1, Q2, Q3** and **Q4** columns.

15. Click **Save**.



16. Repeat from **Step 13** to insert following values in list.

Year	Q1	Q2	Q3	Q4
2019	2000	2500	1500	5000
2018	3000	4000	2000	1500
2017	2500	1500	4000	3000
2016	1500	2500	1000	2000
2015	2000	1000	1500	2500

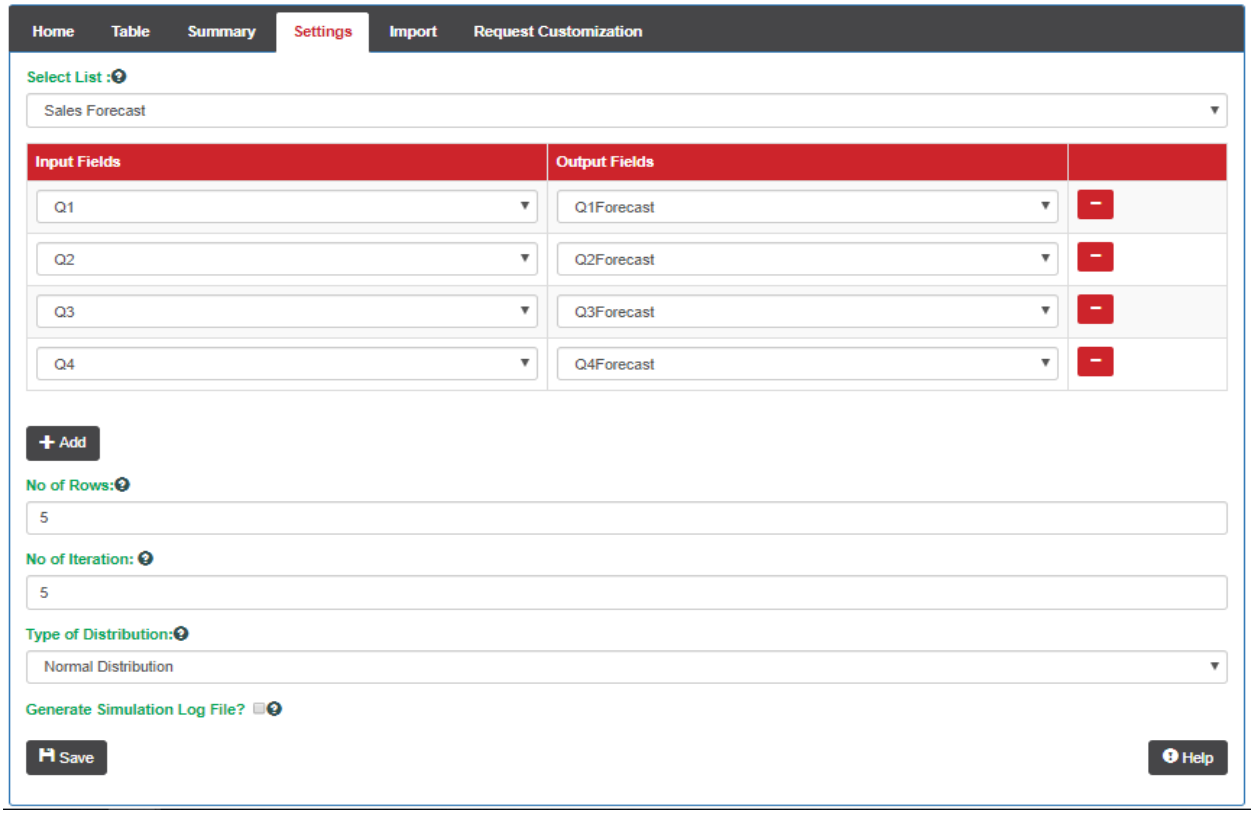


17. Now everything is setup for Monte Carlo Stat Add-In.

7.2. STEP 2 – MONTE CARLO STAT ADD-IN CONFIGURATION

1. Go to Settings tab and configure following settings.
    I. Select **"Sales Forecast"** list from **Select List** dropdown.
    II. Select **Q1, Q2, Q3** and **Q4** in input fields dropdown.
    III. Select **Q1Forecast**, **Q2Forecast**, **Q3Forecast** and **Q4Forecast** from **Output Fields** dropdown.
    IV. Type **5** into **No of Rows** input field.
    V. Type **5** into **No of Iterations** input field.
    VI. Select **Normal Distribution** from **Type of Distribution** dropdown.

VII. Click **Save**.

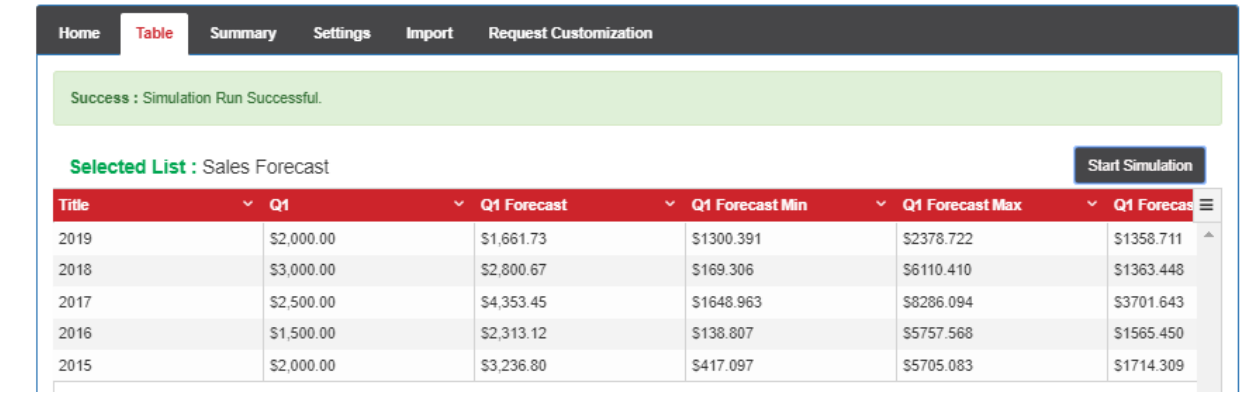


7.3. STEP 3 – RUN SIMULATION

1. After **Save**, Monte Carlo Stat Add-In will redirect to **Table** tab. In the table tab, you will see inserted list values in **Title, Q1, Q2, Q3 and Q4** columns. And **Q1Forecast, Q2Forecast, Q3Forecast and Q4Forecast**

column will be blank. This is because we haven't run Monte Carlo Algorithm Simulation yet.

2. Click **Start Simulation**.
3. After the Simulation is complete, you will see values in **Q1Forecast, Q2Forecast, Q3Forecast and Q4Forecast** and additional fields for each output columns (**Q1Forecast, Q2Forecast, Q3Forecast and Q4Forecast**)..



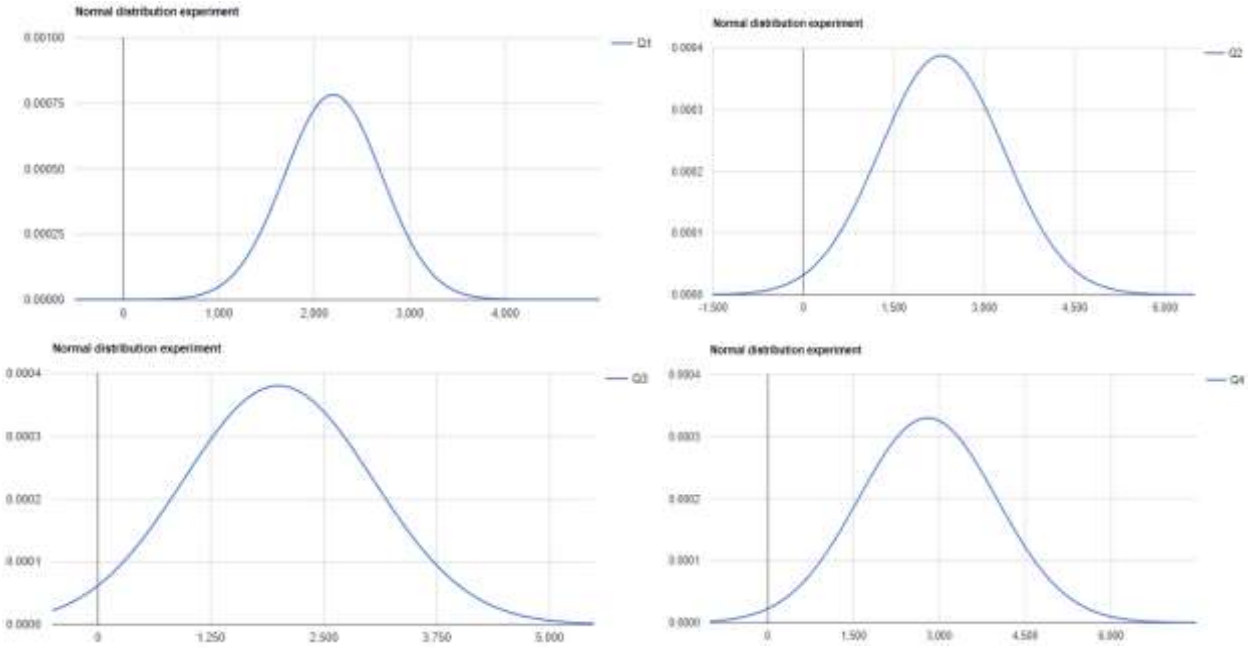
4. These additional columns show the **Minimum, Maximum, 25th Quartile and 75th Quartile** value of each predicted output field value generated during Monte Carlo Algorithm Simulation.
   The value in output columns (**Q1Forecast, Q2Forecast, Q3Forecast and Q4Forecast)** will be inserted in **Sales Forecast** list automatically. So that the next time when you load or refresh **Monte Carlo Stat Add-In**, these output values will be displayed in respective columns rather than empty columns.
   However, additional columns (**Minimum, Maximum, 25th Quartile and 75th Quartile**) values will not be saved or stored anywhere unless user export these into new list. Otherwise on reload of Add-In these columns will disappear and will display only after **Simulation** run.
5. You can export current values and status of list as **Excel, PDF, CSV** and to **New SharePoint List**.

7.4. STEP 4 – VIEW SUMMARY

1. Click **Summary** tab.
2. Summary tab will show summarize view of input columns values in **tabular** form. And **Normal Distribution**

Selected List : Sales Forecast

Field Name	Mean	Median	Standard Deviation	Min	Max	Mode
Q1	2200.000	2000.000	509.902	1500.000	3000.000	2000.000
Q2	2300.000	2500.000	1029.563	1000.000	4000.000	2500.000
Q3	2000.000	1500.000	1048.809	1000.000	4000.000	1500.000
Q4	2800.000	2500.000	1208.305	1500.000	5000.000	1500.000



or **Triangle Distribution** curve (selected from Settings) from input column separately.

3. Just to remind you, as we selected **Normal Distribution** in **Settings** tabs. That's why the curve and predicted values are showing in a **Normal Distribution** manner. If we select **Triangular Distribution**, **Summery** table columns, values and the shape of curve will be change accordingly.

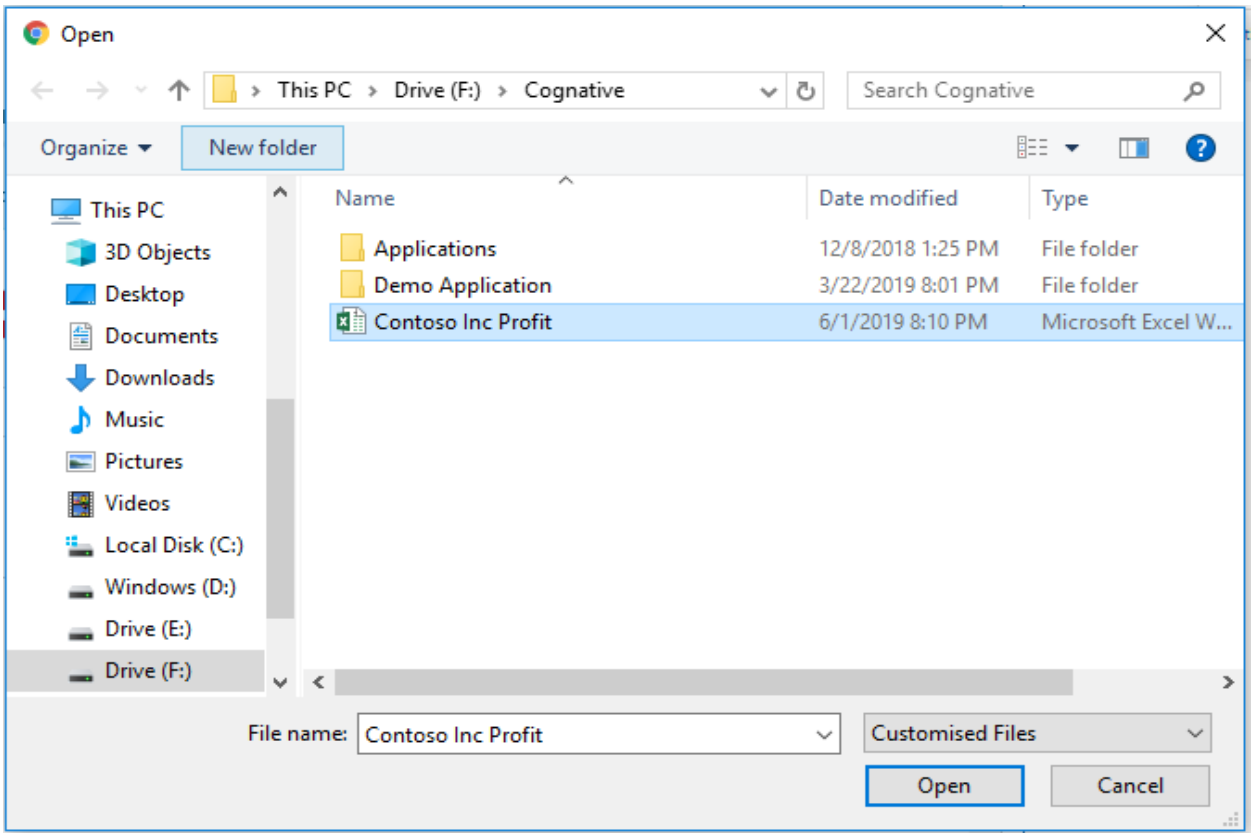
4. Note you can select only **one** distribution type at a time.

7.5. STEP 5 – IMPORT LIST

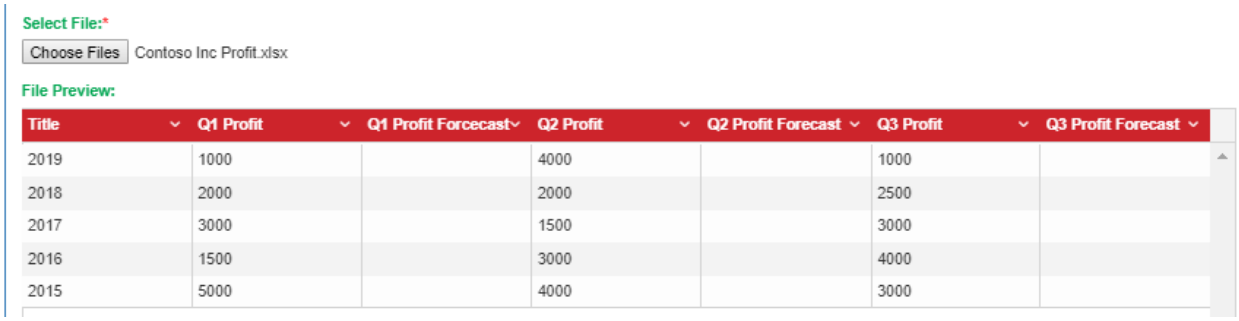
1. Click "**Import**" tab.
2. Now Contoso Inc. want to import Quarterly profit excel file as SharePoint list and forecast values.
3. They have Excel file generated from third party tool with input values of Monte Carlo Stat Add-In.

	A	B	C	D	E	F	G
1	Title	Q1Profit	Q1Profit_Forcecast	Q2Profit	Q2Profit_Forecast	Q3Profit	Q3Profit_Forecast
2	2019	1000		4000		1000	
3	2018	2000		2000		2500	
4	2017	3000		1500		3000	
5	2016	1500		3000		4000	
6	2015	5000		4000		3000	

4. Select file from windows directory.

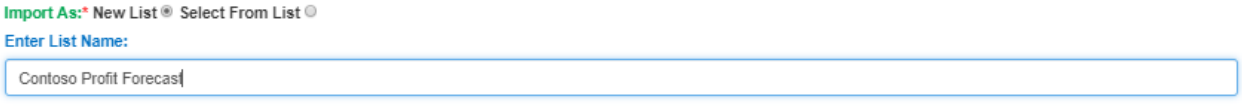


5. After selecting Contoso Inc Profile, you will see a Excel file preview in grid to make sure values are correct.



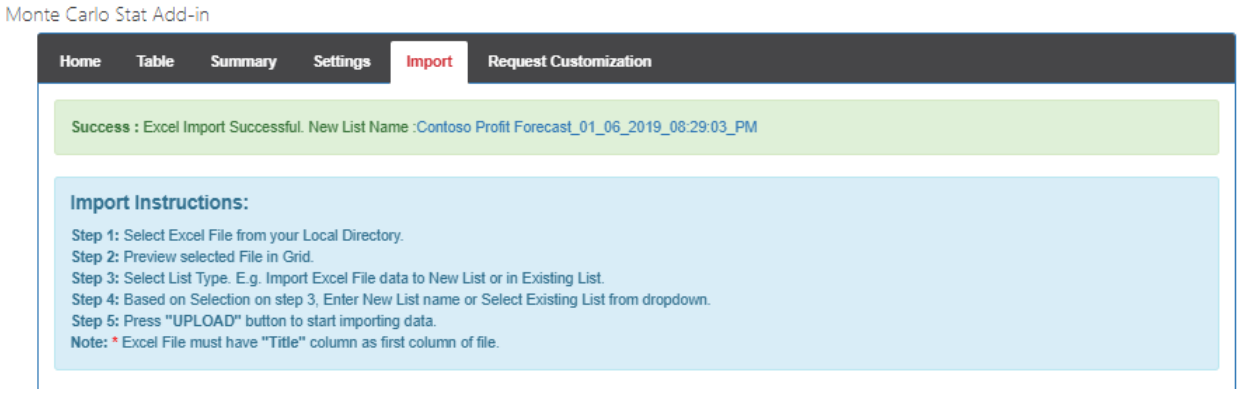
Title	Q1 Profit	Q1 Profit Forecast	Q2 Profit	Q2 Profit Forecast	Q3 Profit	Q3 Profit Forecast
2019	1000		4000		1000	
2018	2000		2000		2500	
2017	3000		1500		3000	
2016	1500		3000		4000	
2015	5000		4000		3000	

6. There must be a “Title” column in the Excel file with unique values. Other columns should contain numeric and date type values. Otherwise it will generate an error during import process.
7. Choose “New List” option from below and enter the list name (Contoso Profit Forecast) you want to create with uploaded Excel values.

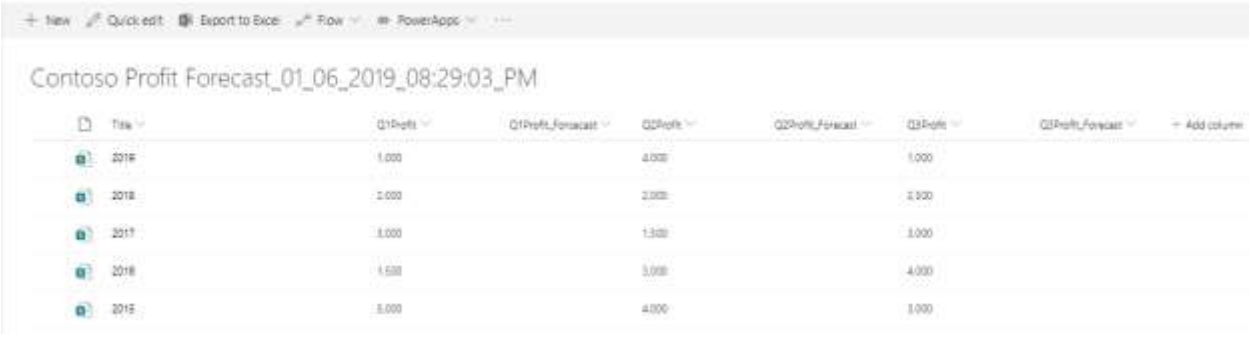


8. Click Upload.

9. After Upload, a Success message will be displayed on top of Import tab with new list name.

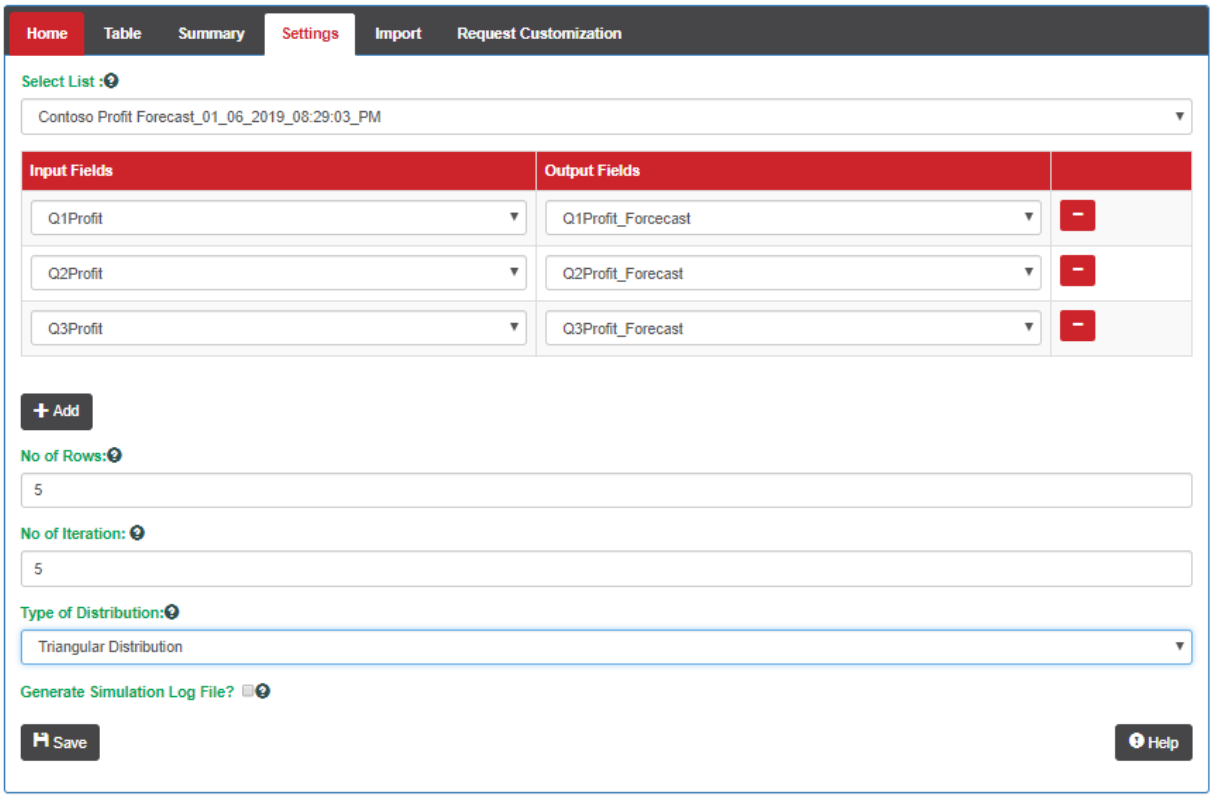


10. Click on list name “Contoso Profit Forecast_01_06_2019_082903_PM” to open list in SharePoint view. You can also find lists in Site Content section.



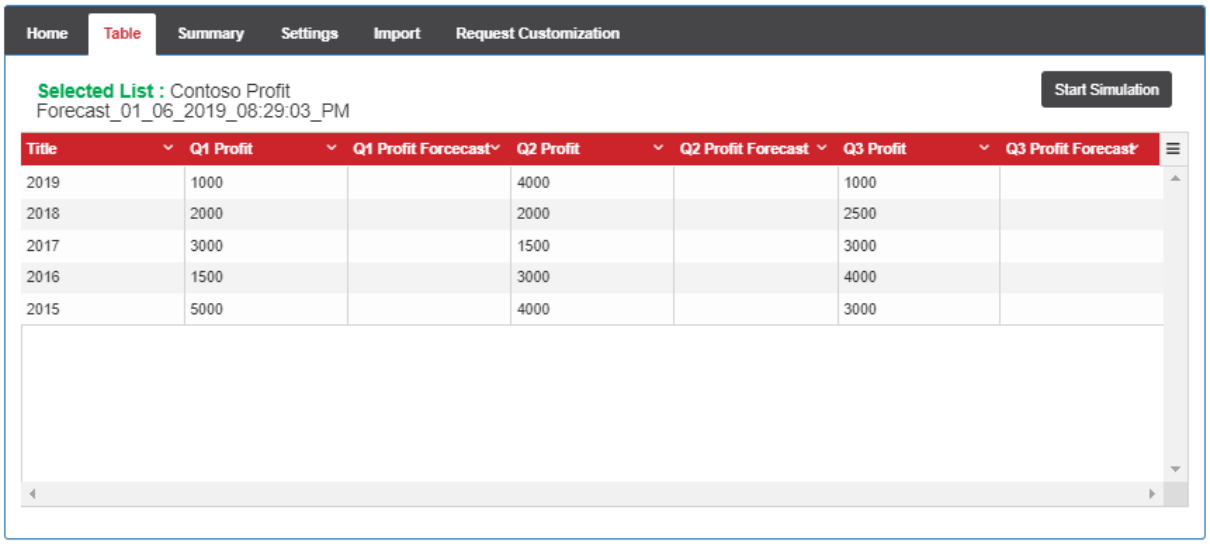
11. Now for forecasting, select “Contoso Profit Forecast_01_06_2019_082903_PM” from settings tab. Select input and output columns and save settings as we have done before with Sales Forecast list.

Monte Carlo Stat Add-in

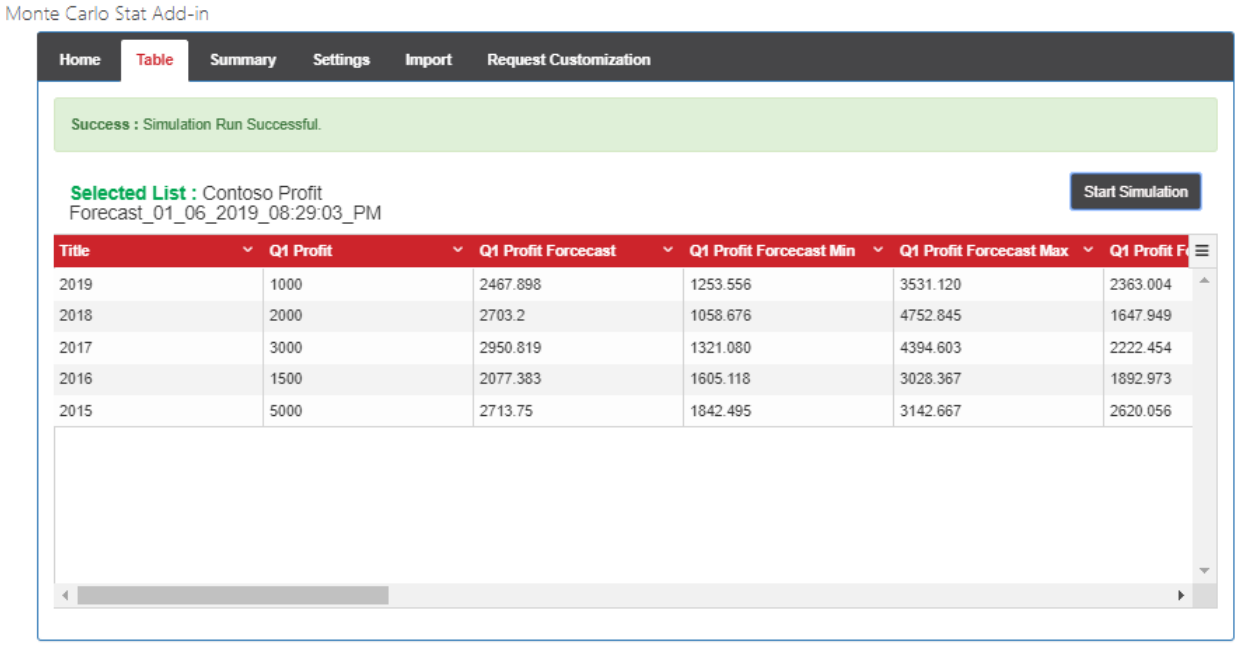


12. It will then redirect to Table tab.

Monte Carlo Stat Add-in

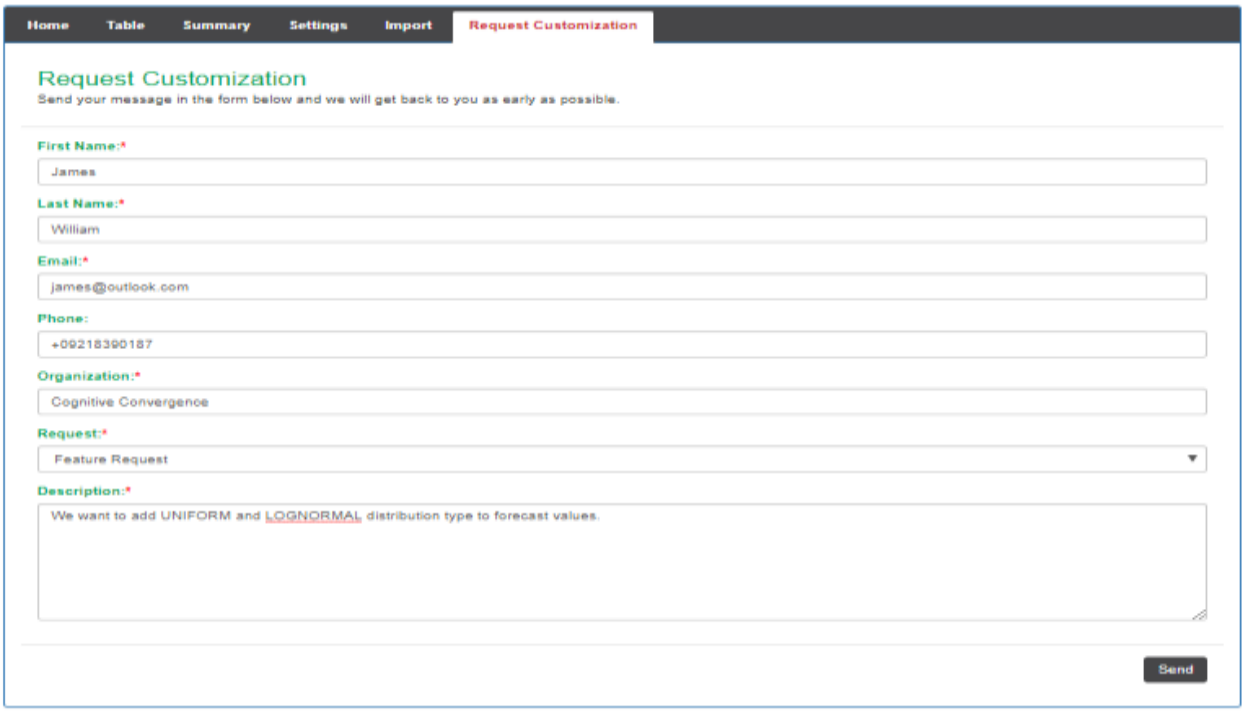


13. Click Start Simulation.



7.6. REQUEST CUSTOMIZATION

1. If a user wants to give some feedback regarding an error of an Add-In, they may follow these steps.
2. Go to Request Customization tab.
3. Fill out the required fields and click Send.
4. It will open the users default mail application, auto-complete the completed fields and it address it to



AppSupport@zagros.onmicrosoft.com. This address may also be used for other feedback, requests for customizations and comments.