eniacSim

User Manual

for the eniacSim Excel add-in

Version 1.01, February 2024

1 Getting Started

1.1 Installation

1.1.1 System requirements

eniacSim requires a 64-bit version of Microsoft Excel and was developed and tested on Excel 365 for macOS. All 64-bit versions (Excel 2016 and newer) for macOS and Windows should work properly. If you are not sure, you should get a free trial version and check for the compatibility of your system.

1.1.2 Download

You can obtain the latest version of eniacSim via the website www.eniacsim.com. A free trial version can be downloaded without registration. To receive a full version, you need to buy a license via the website. After successful purchase, you will be able to download a full version of the add-in and activate it with your license key.

1.1.3 Installation

Save the add-in (file with the extension .xlam) to your program files directory, open Excel and activate the add-in. If you are not sure how to install an add-in, see Microsoft support for adding and activating add-ins under https://support.microsoft.com/en-us/office/add-or-remove-add-ins-in-excel-0af570c4-5cf3-4fa9-9b88-403625a0b460.

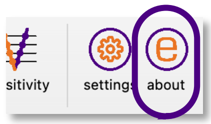
As add-in files downloaded from the Internet will be blocked by default, you may need to unlock the file by removing the "Mark of the Web" in the properties of the downloaded file. In case you have problems in removing the security features, please see Microsoft documentation under https://learn.microsoft.com/en-us/deployoffice/security/internet-macros-blocked.

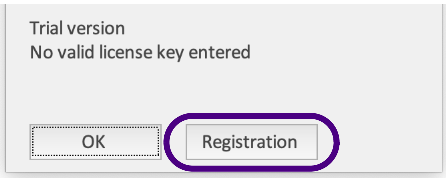
1.1.4 Opening Excel

If the installation process was successful, Excel will open with a new item named "eniacSim" in the ribbon, showing the menu items of the add-in. All functions of eniacSim can be controlled from this ribbon.

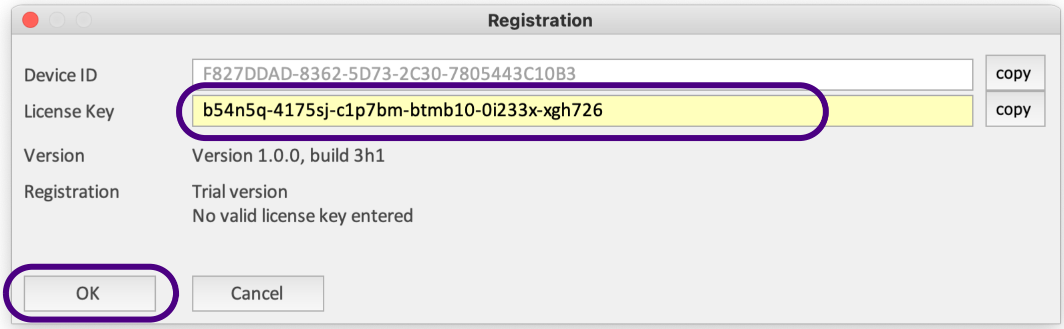
1.2 License Activation

After you made a purchase of a license via the website, you will receive your license key for activation of the add-in by email. In the ribbon, click the about button and in the about window click the Registration button.

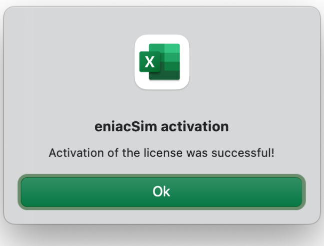




Enter the license key that you have received by email in the registration form and press OK.



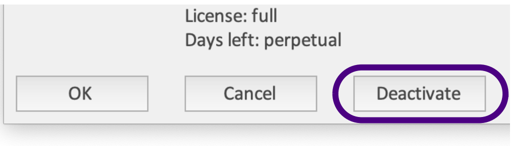
The add-in connects to the website and activates the add-in. You should receive the following message for a successful registration.



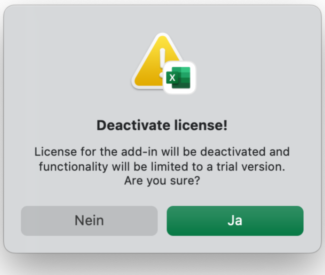
In case the activation was not successful, you can generate an Activation Code via the license management on the eniacSim website (see 1.4 for further details).

1.3 License Deactivation

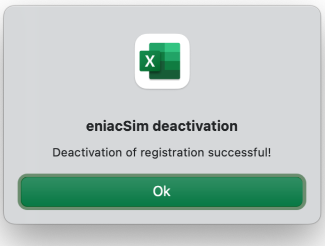
If you change your computer or want to activate the license on another computer, you can deactivate your license on the current device and use the license key for a new activation on another device. For deactivation, follow the same steps as in 1.2 and click the Deactivate button in the registration window.



You will receive a warning message that the license of the add-in on the current device will be deactivated an functionality will be limited to a trial version.



After confirming by pressing Yes, the license will be deactivated. The license key can now be used for a new activation on any other computer.



Please keep in mind that due to security reasons, you have to wait for 24 hours before you can re-activate the same device with a license key after deactivation of a license.

1.4 License Management

On the eniacSim website, you can find a My License page for license management (see https://www.eniacsim.com/license). Here, you can

- retrieve your purchased license keys,
- get download access to the newest version of the add-in,
- generate a device-bound Activation Code to activate a license on a device, or
- enter a Deactivation Code from your device in order to release a license key for a new activation.

As no personal data is stored in the license management directly, you have to enter your email address that was used for the purchase of the license and will receive a one-time access code to enter the license management that is valid for 10 minutes.

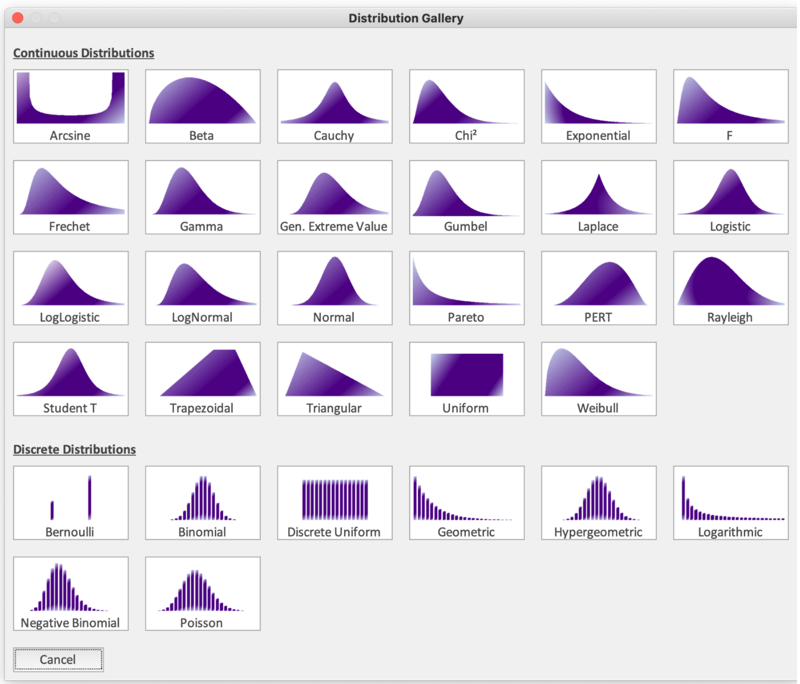
2 Setting Up a Simulation Model

Every simulation model is based on an ordinary calculation model that is used for the simulation. In order to transform your singular calculations into a predictive model, you have to define risky input factors as assumptions and to mark calculation output cells as forecasts.

During each simulation cycle, your defined assumption cells will be assigned a new random value and the whole model is recalculated. The values of all input and output cells will be stored for each simulation cycle for later analysis and the results will be shown by different charts.

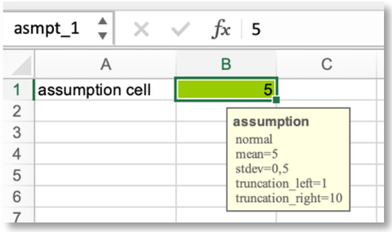
2.1 Defining Assumptions

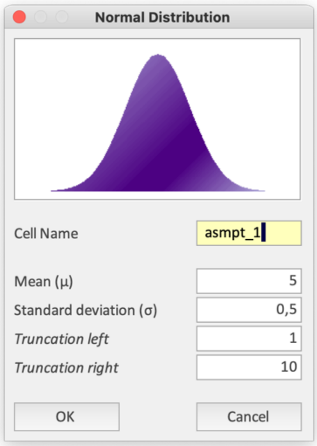
With eniacSim, fixed value input cells can be defined as random variables following specified probability distributions. These cells are called Assumptions. To allocate such an Assumption to a specific cell, simply press the assumption button on the ribbon and the distribution gallery window will open.



When you select any of the probability distributions, the corresponding window for the probability distribution definition will be opened. If you have defined an Assumption already and press the assumption button in the ribbon, the corresponding probability distribution window will open directly.

In the probability distribution window you have to enter the cell name and the parameters of the probability distribution and confirm the settings with OK.

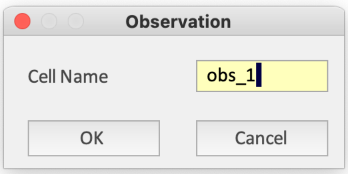


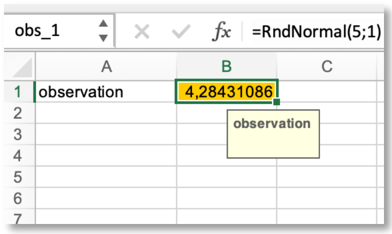


All parameters will be stored directly in the spreadsheet cell without interfering with normal Excel functionality[1], the cell name will be saved and the assumption cell will be marked green by default[2].

2.2 Defining Observations

Input factors can be defined either as an Assumption in a fixed value cell or as an Observation in any other cell. By pressing the observation button on the ribbon you can assign a cell name to the cell and define it as an Observation. The information that the cell is defined as an Observation will be stored directly in the spreadsheet cell[1], the cell name will be saved and the observation cell will be marked orange by default[2].





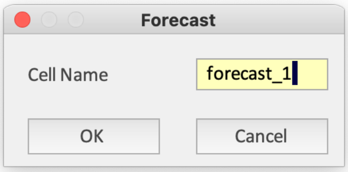
Observations can be used to mark complex cell definitions with references to other cells or random formulas as input cells. In addition, defining Observations is a good method to uncover the impact of changes on the output results when running a sensitivity or an OFAT analysis of the model. See a recommended approach for model development and analysis and how to best use Observations in chapter 3.7.

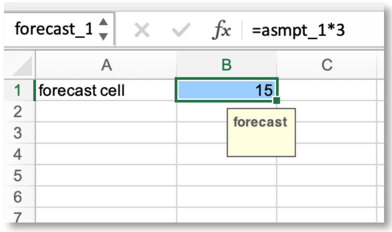
1 All data is stored as an input message in the data validation field of a spreadsheet cell. By this approach, all relevant information can be stored directly in the cell without interfering with normal spreadsheet functionality and without requiring any hidden worksheets. The Excel files can be exchanged with users that do not have eniacSim installed without losing the information for Assumptions, Observations and Forecasts. See chapter 6 for more technical details.

2 See chapter 4 for customising user settings.

2.3 Defining Forecasts

Each output cell that is relevant for the calculation and for future analysis should be marked as Forecast cell by pressing the forecast button on the ribbon and assigning a cell name in the forecast window. The information that the cell is defined as a Forecast will be stored directly in the spreadsheet cell[1], the cell name will be saved and the forecast cell will be marked blue by default[2].

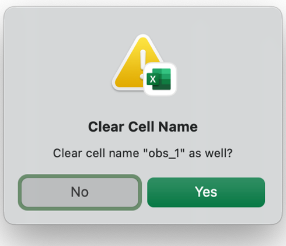




2.4 Clear Cell Definitions

Cell definitions for Assumptions, Observations and Forecasts can be cleared from the spreadsheet by pressing the clear button in the ribbon. All stored information will be cleared and you will be asked, if the assigned cell name shall be cleared as well.

If a Forecast cell shows the random formula at the time you press the clear button, the expected value of the formula will be written as a fixed value in the cell before the parameter information is cleared.

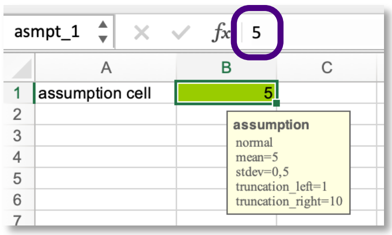


2.5 Switching between Expected Value and Random Formula Mode

There are two cell modes for defined Assumptions, either fixed values (calculated as expected values of the defined probability distributions) or random values (calculated with the random formulas and the defined parameters). You can switch between these modes by pressing the corresponding buttons in the ribbon.

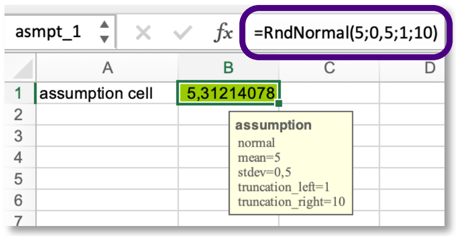
write ev will write the fixed values in all Assumption cells

E.g. the expected value of the previously defined probability distribution is "5"



write rnd will write the random formulas in all Assumption cells

E.g. the formula of the defined distribution is "=RndNormal(5;0,5;1;10)"



If the mode for random formulas is selected, every input in the spreadsheet leads to a new generation of random numbers and to a recalculation of the whole spreadsheet. A manual recalculation can be achieved by pressing fn + F9 on macOS or F9 on Windows devices.

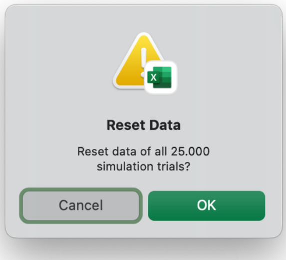
For most probability distributions, the expected value is calculated as the mean or the median value of the probability distribution. The values used are shown for all probability distribution at the end of each definition under "EV" in chapter 5.

Please keep in mind to set the display mode to expected values by pressing write ev before exchanging Excel files with users that do not have eniacSim installed as they will get error messages otherwise because the probability formulas are not known.

3 Running a Simulation

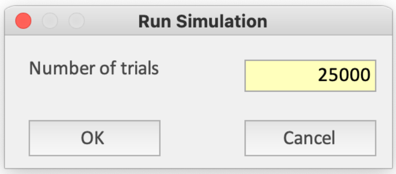
3.1 Reset Simulation Data

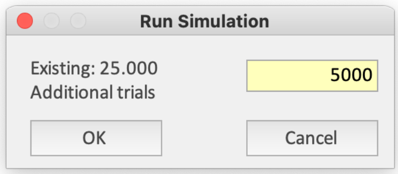
Before a new simulation is started, existing input and output data from previous simulations can be cleared. A warning message will ask the user if all existing data shall be deleted.



3.2 Running a Simulation

When pressing the simulation button in the ribbon, a dialogue asks for the number of (new) simulation iterations. If a data set exists already, new simulation cycles are added on top of the existing simulations. A maximum of 1 million iterations[3] can be performed. In practice, 5 or 10 thousand iterations are usually sufficient to get reliable output data.





If no number of trials is entered in the input field and no simulation data exists, a default value of 10 is set to get a very quick result.

If no number of new trials is entered in the input field and simulation data from previous simulations exist already, the histogram and scatterplot charts are redrawn without additional simulations. This can be useful, if the chart layout has been changed in the user settings (see chapter 4) and the charts need to be redrawn without additional simulations.

After the simulation is finished, the results are shown in the simulation results worksheet.

[3] In the trial version, the maximum number of iterations is 1.000, in the light version, the maximum number of iterations is 10.000.

3.3 Simulation Results and Scatterplot Charts

The simulation worksheet shows

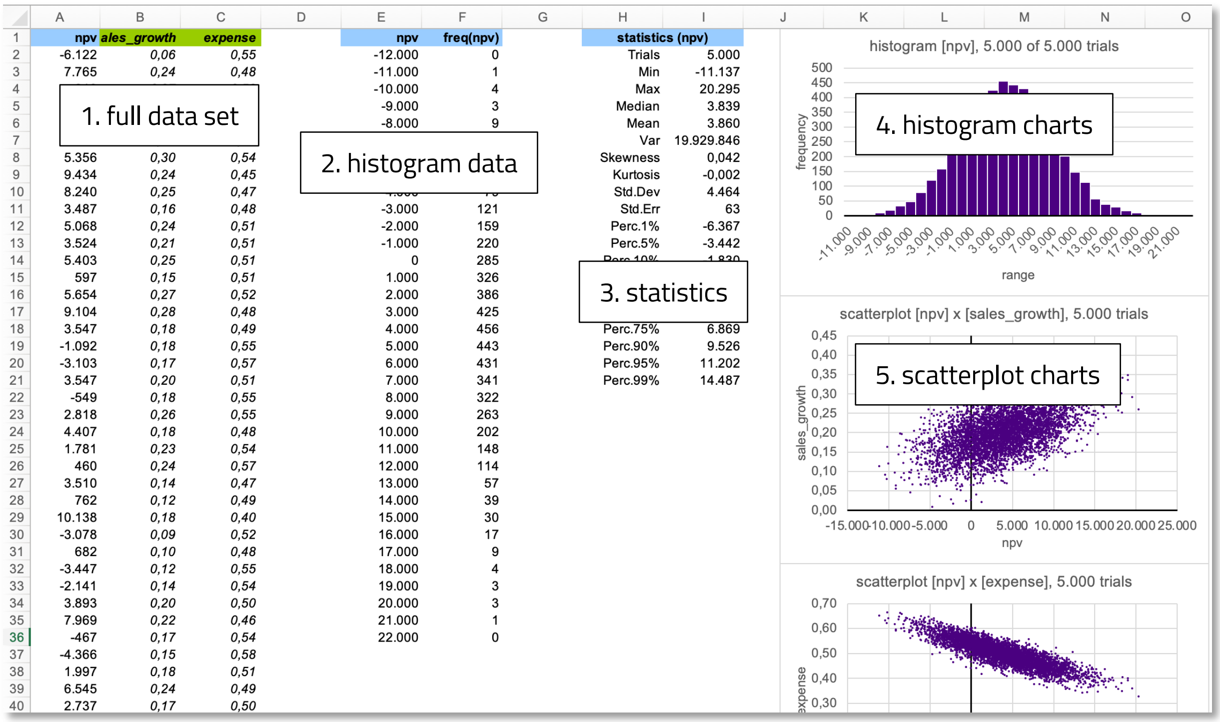
1. the full data set of all Assumption, Observation and Forecast cells from all simulation iterations, and
2. scatterplot charts for each pair of Forecast and Assumption/Observation cells.

If you are working with many random variables, the creation of scatterplot charts may take some time. You can disable the drawing of scatterplot charts in the user settings (see chapter 4).

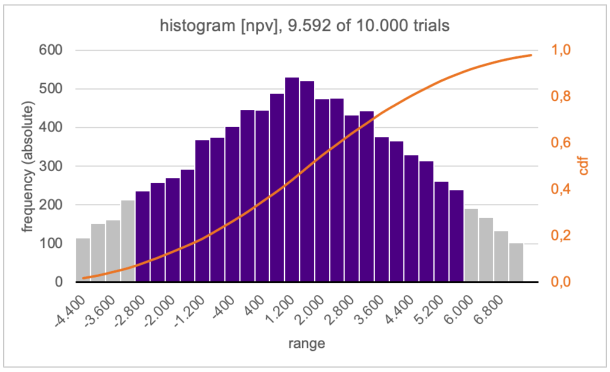
3.4 Histogram and Statistics

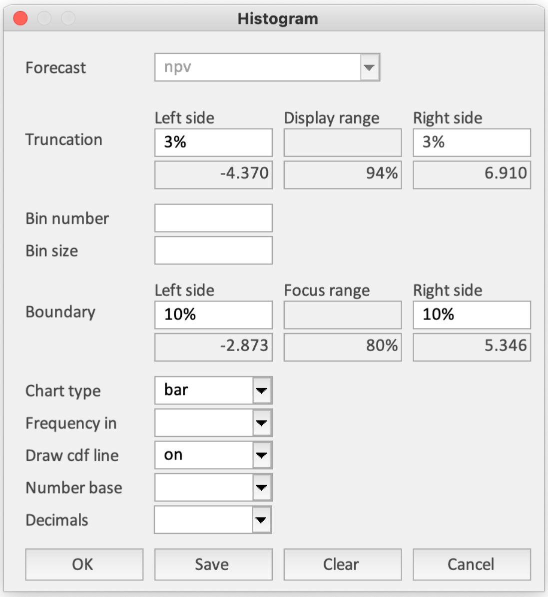
The statistics worksheet shows

1. the full data set of all calculated Assumptions, Observations and Forecasts,
2. the frequency rows and data for the cumulative distribution function for all Forecasts,
3. main statistics for all Forecasts (minimum, maximum, median, mean, variance, skewness, kurtosis, standard deviation, standard error of the mean and percentiles),
4. a histogram chart for each defined Forecast, and
5. a scatterplot chart for each combination of Forecast and Assumption.



By clicking on a histogram chart, a menu opens to change several display parameters of the histogram chart:





Forecast — Dropdown to select e forecast chart

Truncation — In order to not display extreme values (outliers) on the histogram, you can truncate the chart and enter up to two values for the truncation on the left side, right side or the display range in absolute or relative values. These settings overrule the *Histogram truncation* setting in the User Settings. Possible combinations could be:

- Left side: -4.000 Right side: 5%
- Left side: 10% Right side: 10%
- Left side: -4.000 Display range: 7.000
- Display range: 80%
- Display range: 80% Right side: 5%

Bin number — Number of bars for the histogram chart

Bin size — Size of each single bar in the histogram chart

Boundary — With Boundary, a focus on a certain part of the histogram can be defined. Similar to Truncation, up to two values (left side, right side or focus range) can be entered to define the boundaries.

Chart type — Overrules the *Histogram chart type* from the User Settings (bar, area or line chart)

Frequency in — Overrules the *Show histogram frequency in* setting from the User Settings (% or values)

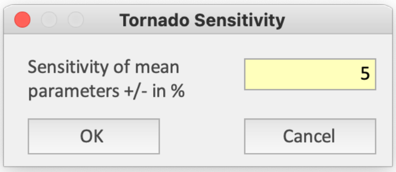
Draw cdf line — Overrules the *Draw cdf line in histograms* setting from the User Settings

Number base — Select the number base (1, thousands, millions or billions)

Decimals — Select how many decimal places are displayed

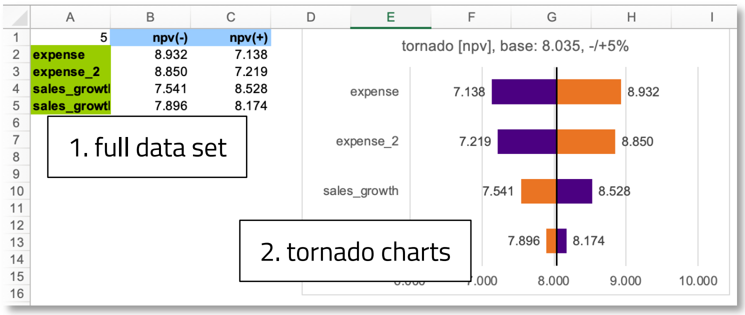
3.5 Tornado Analysis

The tornado analysis performs a special simulation in which all but one input factors remain constant. Each input factor is then changed by the entered sensitivity, once +sensitivity and once –sensitivity. If no value is entered, ±3% is taken by default.



The tornado chart worksheet shows

1. the full data set of the sensitivity calculations, and
2. the tornado chart for each Forecast cell.

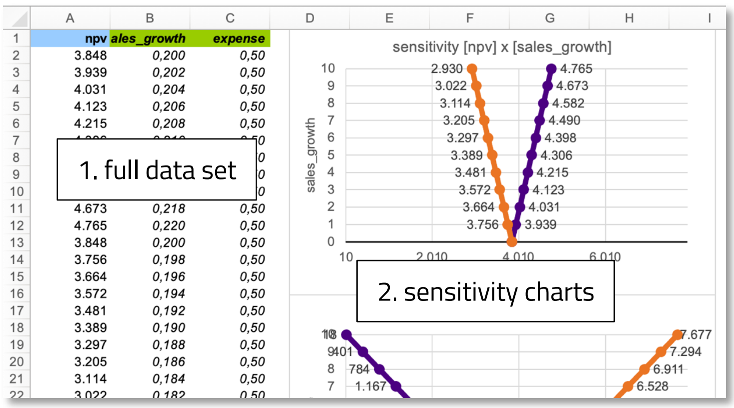


3.6 Sensitivity Analysis

The sensitivity analysis performs special simulation calculations in which all but one input factors remain constant. Following a ceteris paribus approach, the variable input factor is scaled step by step from 0% to -10% and from 0% to +10%. The number of sensitivities can be adjusted in the customer user settings. The result is typically a V-shaped chart, showing the impact of a change in one Assumption on the defined Forecasts.

The sensitivity analysis worksheet shows

3. the full data set of the sensitivity calculations, and
4. the V-shaped sensitivity charts for each pair of Forecast and Assumption/Observation cells.



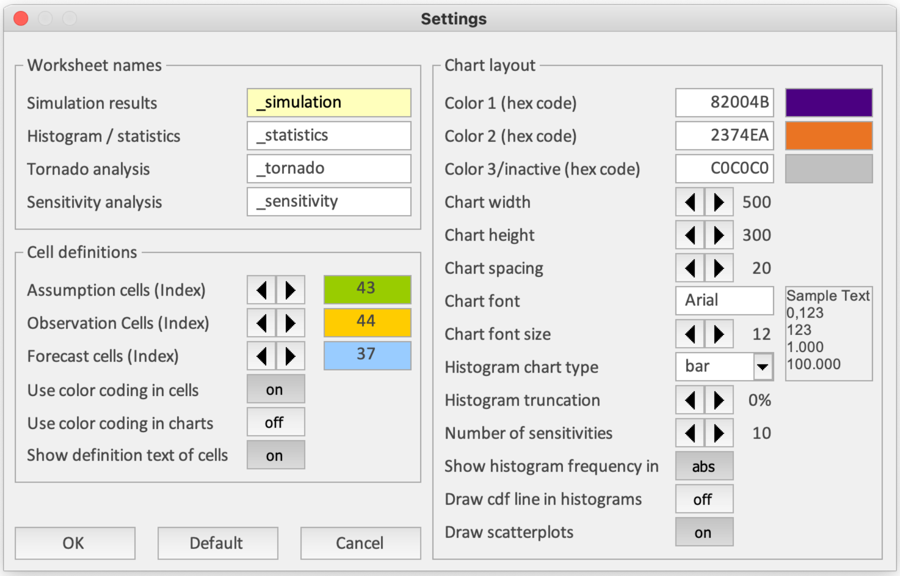
3.7 Recommended Approach for Model Development and Analysis

A proven way to develop meaningful simulation models is to

1. start with the declaration of output cells as Forecasts,
2. define fixed values that are potentially strong influence factors as Observations and perform a tornado and sensitivity analysis,
3. specify the strongest input factors as Assumptions and decline Observations with minor influence,
4. perform a Monte Carlo simulation with a low number of iterations (e.g. 100), analyze the simulation results, check for plausibility, etc.
5. go back to 3. and refine the parameters in your Assumptions,
6. perform a Monte Carlo simulation with a higher number of iterations, run a tornado and sensitivity analysis and interpret the results.

4 Customizing User Settings

In the full licensed version, certain user settings can be customized and saved, e.g. to consider corporate design colors or large dimensions of device screens. The settings window can be opened by pressing the settings button on the ribbon.



Worksheet names

Simulation results	Name of Excel worksheet that shows the simulation data and scatterplots
Histogram / statistics	Name of Excel worksheet that shows the histograms and data statistics
Tornado analysis	Name of Excel worksheet that shows the tornado chart
Sensitivity analysis	Name of Excel worksheet that shows the sensitivity analysis

Cell definitions

Assumption cells	Color index code for marking Assumption cells in the spreadsheet
Observation cells	Color index code for marking Observation cells in the spreadsheet
Forecast cells	Color index code for marking Forecast cells in the spreadsheet
Use color coding in cells	Toggle color coding on/off
Use color coding in charts	Marks the description in the axis according to the color coding
Show definition text	Toggle whether definition for Assumption cells is shown as pop-up

Chart layout

Color 1	First color in charts, has to be entered as a hex code
Color 2	Second color in charts, has to be entered as a hex code
Color 3	Color for inactive range (out of boundary settings) in histograms
Chart width	Width of charts in pixels
Chart height	Height of charts in pixels
Chart spacing	Spacing between charts in pixels
Chart font	Default font for chart title and chart axes, to be entered by name
Chart font size	Default font size for chart axes

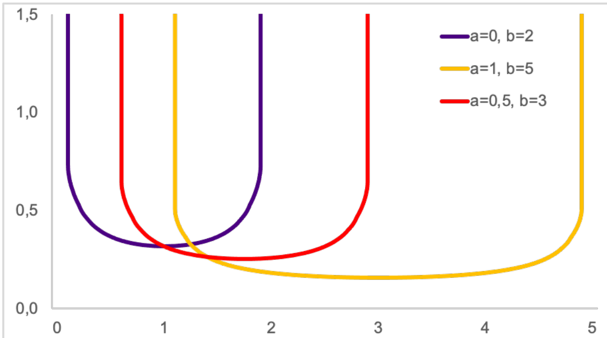
Histogram chart type	Show histograms as bar, area or line chart
Histogram truncation	Truncate n-percentile out of the histogram (suppresses extreme values)
Number of sensitivities	Default number of 1%-steps for the sensitivity analysis
Show histogram frequency	Toggle between % and absolute values
Draw cdf line	Draw additional cumulated distribution function (cdf) line in histograms
Draw scatterplots	Draw scatterplots after simulation or not

5 Distribution Functionsl

5.1 Continuous Distribution Functions

5.1.1 Arcsine Distribution

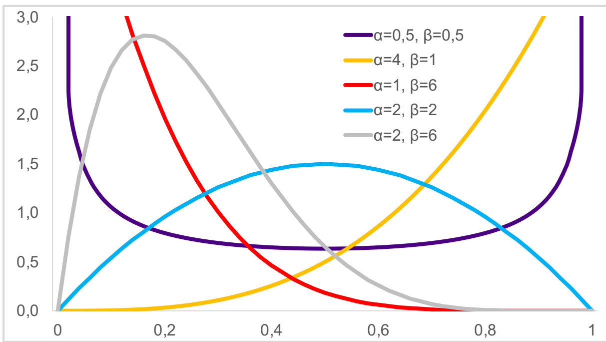
The Arcsine distribution is the general version in the notation by the two endpoints of the support interval *a* and *b*.



Parameters		-∞ < a < b < +∞
Domain		a < x < b
VBA formula		= RndArcsine (a, b)
	a	left endpoint, location parameter
	b	right endpoint
EV		mean value = $\frac{a+b}{2}$

5.1.2 Beta Distribution

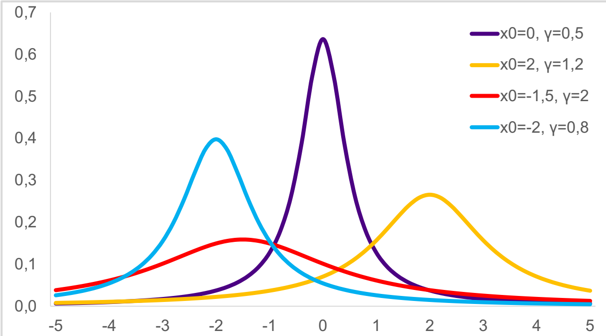
The Beta distribution is the four parameter version scaled between the minimum and the maximum. Standard Beta distribution is scaled in the interval 0 ≤ x ≤ 1, with the optional parameters set, the interval is *min* ≤ x ≤ *max*.



Parameters		α > 0, β > 0, min < max
Domain		min ≤ x ≤ max
VBA formula		= RndBeta (α, β [,min][,max])
	α	left shape parameter
	β	right shape parameter
	min	*optional, a lower boundary on the left side, default value = 0*
	max	*optional, an upper boundary on the right side, default value = 1*
EV		mean value = min+ $\frac{\alpha}{\alpha+\beta}$ (max-min)

5.1.3 Cauchy Distribution

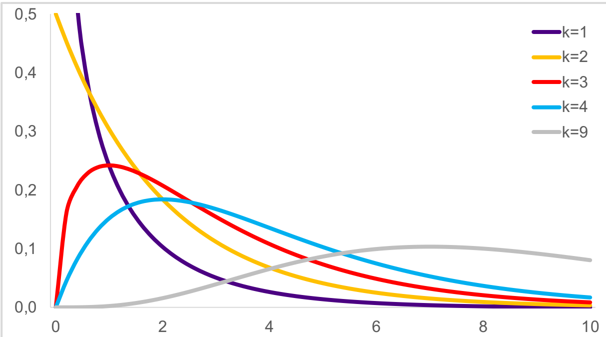
The Cauchy distribution is the distribution of the ratio of two independent normally distributed random variables with mean zero. Compared to the normal distribution, the Cauchy density function has a higher peak and lower tails.



Parameters	$-\infty < x_0 < +\infty$, $\gamma > 0$
Domain	$-\infty < x < +\infty$
VBA formula	= RndCauchy (x_0, γ)
x_0	location parameter
γ	scale parameter
EV	median value = x_0

5.1.4 Chi²

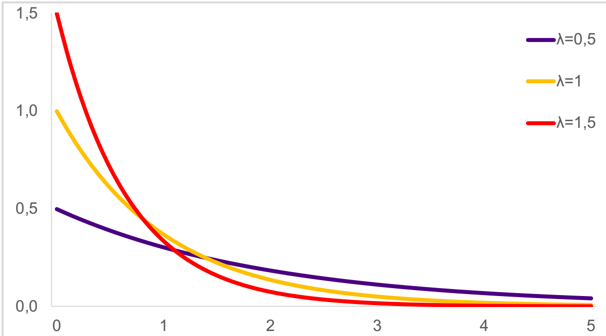
The Chi² distribution is the distribution of a sum of the squares of k independent standard normal random variables. It is one of the most widely used probability distributions in hypothesis testing and in construction of confidence intervals.



Parameters	k > 0, integer number
Domain	$x \geq 0$
VBA formula	= RndChi2 (k)
k	degrees of freedom
EV	mean value = k

5.1.5 Exponential Distribution

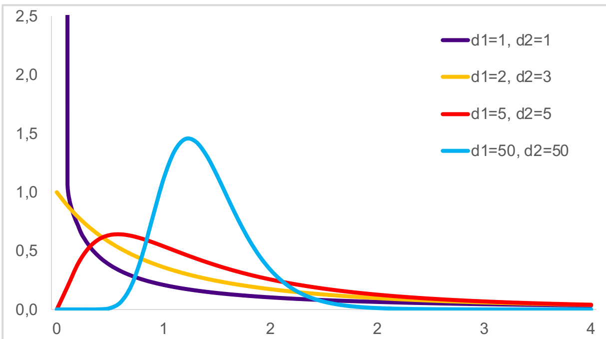
The Exponential distribution is the probability distribution of the time between events in a Poisson point process.



Parameters	$\lambda > 0$
Domain	$x \geq 0$
VBA formula	= RndExponential (λ)
λ	rate (or inverse scale) parameter
EV	mean value = $^1/_\lambda$

5.1.6 F-Distribution

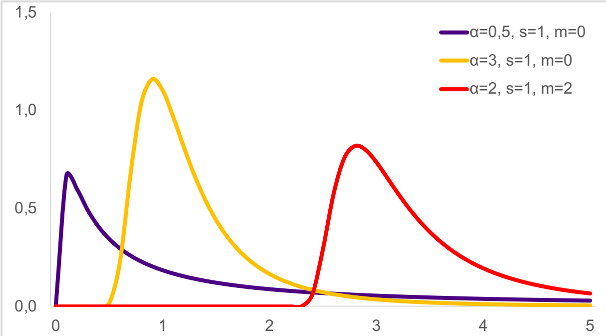
The F-distribution arises frequently as the null distribution of a test statistic It arises from ratios of sums of squares when sampling from a normal distribution.



Parameters	$d_1 > 0$, integer number	$d_2 > 0$, integer number
Domain	$x > 0$	
VBA formula	= RndF (d_1, d_2)	
d_1	degrees of freedom 1	
d_2	degrees of freedom 2	
EV	for $d_2 > 2$: mean value = $\frac{d_2}{d_2-2}$ for $d_2 \leq 2$: constant value = d_2	

5.1.7 Fréchet Distribution

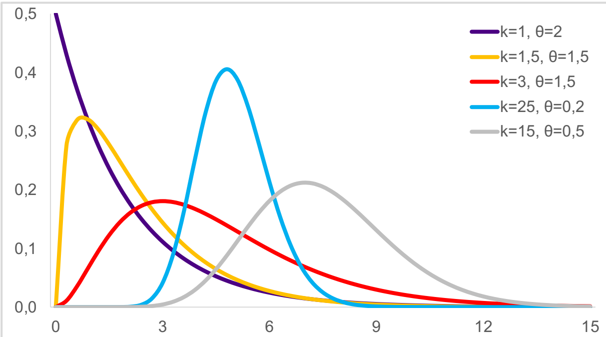
The Fréchet distribution is applied to extreme events in hydrology, such as annually maximum one-day rainfalls, or in decline curve analysis of the time series data of energy production.



Parameters	α > 0, s > 0, -∞ < m < +∞
Domain	x > m
VBA formula	= RndFrechet (α, s, m)
α	shape parameters
s	scale parameter
m	minimum parameter
EV	median value = m+$\frac{s}{\sqrt[\alpha]{ln(2)}}$

5.1.8 Gamma Distribution

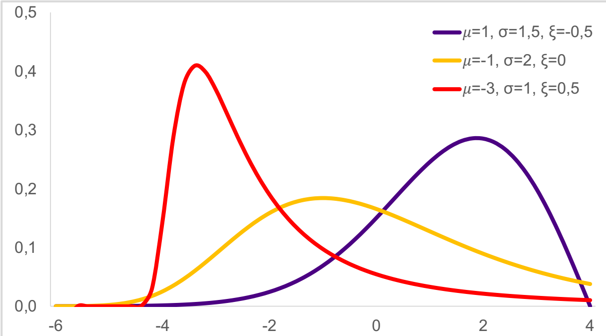
The Gamma distribution models the time required for k events to occur, when the events occur randomly in a Poisson process with a mean time between events of θ. It is used to model the size of insurance claims and rainfalls



Parameters	k > 0, θ > 0
Domain	x ≥ 0
VBA formula	= RndGamma (k, θ)
k	shape parameters
θ	scale parameter
EV	mean value = kθ

5.1.9 Generalized Extreme Value (GEV) Distribution

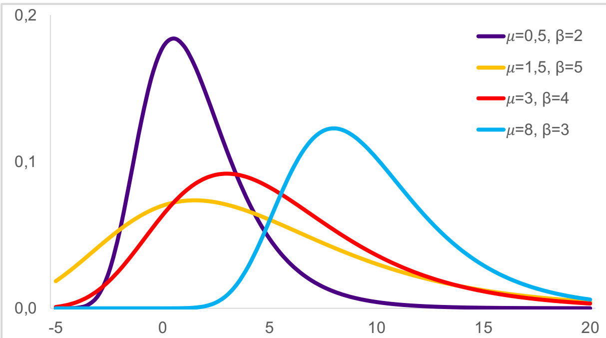
The Generalized Extreme Value (GEV) distribution is a family of three different types of probability distributions and is widely used in the treatment of "tail risks" in insurance and finance fields.



Parameters	$-\infty < \mu < +\infty$, $\sigma > 0$, $-\infty < \xi < +\infty$		
Domain	for $\xi<0$: $-\infty < x < \mu-\frac{\sigma}{\xi}$	for $\xi=0$: $-\infty < x < +\infty$	for $\xi>0$: $\mu-\frac{\sigma}{\xi} < x < +\infty$
VBA formula	= RndGEV (μ, σ, ξ)		
μ	location parameter		
σ	scale parameter		
ξ	shape parameter		
EV	median value = $\begin{cases} \mu+\sigma\frac{(\ln 2)^{-\xi}-1}{\xi} & \text{, if } \xi\neq0 \\ \mu-\sigma \ln\ln 2 & \text{, if } \xi=0 \end{cases}$		

5.1.10 Gumbel Distribution

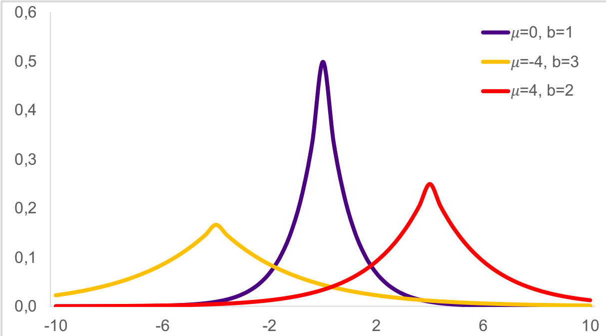
The Gumbel distribution is used to model the distribution of the maximum (or the minimum) of a number of samples of various distributions, e.g. the maximum level of a river in a particular year if there was a list of maximum values for the past ten years.



Parameters	$-\infty < \mu < +\infty$, $\beta > 0$
Domain	$-\infty < x < +\infty$
VBA formula	= RndGumbel (μ, β)
μ	location parameters
β	scale parameter
EV	mean value = $\mu+\beta\gamma$, where γ = Euler-Mascheroni constant (0,5772156649...)

5.1.11 Laplace Distribution

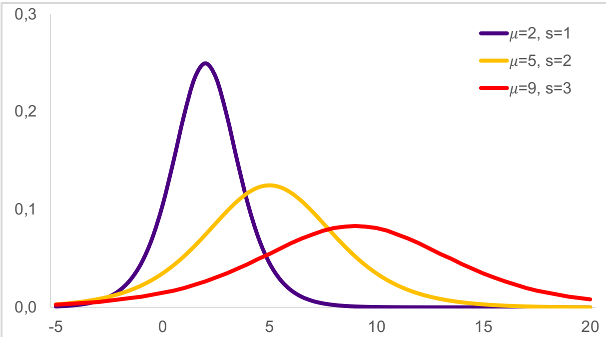
The Laplace distribution has applications in hydrology and finance. It is used to address problems of skewness, kurtosis and the volatility smile that might occur when using a normal distribution.



Parameters	$-\infty < \mu < +\infty$, b > 0
Domain	$-\infty < x < +\infty$
VBA formula	= RndLaplace (μ, b)
μ	location parameters
b	scale parameter
EV	mean value = μ

5.1.12 Logistic Distribution

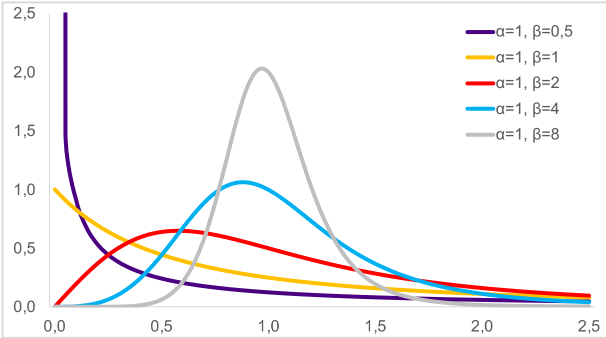
The Logistic distribution is similar to the Normal distribution but somewhat more peaked. It is commonly used in demographic and economic modelling.



Parameters	$-\infty < \mu < +\infty$, s > 0
Domain	$-\infty < x < +\infty$
VBA formula	= RndLogistic (μ, s)
μ	location parameters
s	scale parameter
EV	mean value = μ

5.1.13 LogLogistic Distribution

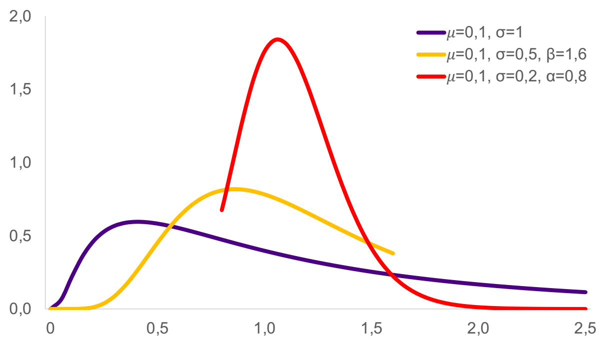
The LogLogistic distribution is used in survival analysis as a parametric model for events whose rate increases initially and decreases later. In economics it is used as a simple model of the distribution of wealth or income.



Parameters		α > 0, β > 0
Domain		x ≥ 0
VBA formula		= RndLogLogistic (α, β)
	α	scale parameters
	β	shape parameter
EV		mean value = $\frac{\alpha\pi/\beta}{\sin(\pi/\beta)}$, if β > 1
		median value = α, if β ≤ 1

5.1.14 Lognormal Distribution

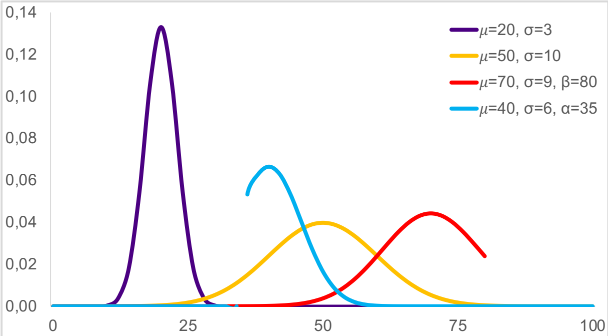
The Lognormal distribution is widely used in practice for the description of natural growth processes with many small percentage changes.



Parameters		μ > 0, σ > 0, 0 > α < β
Domain		max(0, α) ≤ x ≤ min(β, +∞)
VBA formula		= RndLogNormal (μ, σ [,α][,β])
	μ	mean
	σ	standard deviation
	α	*optional, truncation left side, default value = 0*
	β	*optional, truncation right side, default value = +∞*
EV		mean value = $\exp\left(\mu+\frac{\sigma^2}{2}\right)$

5.1.15 Normal Distribution

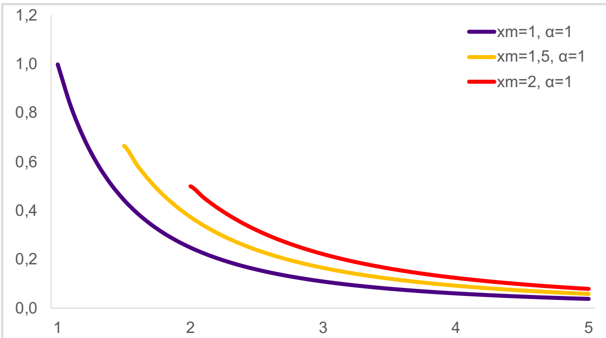
The Normal distribution is used in practice to simulate naturally occurring variables. In finance, many changes are assumed to be normally distributed although in recent times distribution types with heavy tails are assumed to be more appropriate.



Parameters	$\mu > 0$, $\sigma > 0$, $\alpha < \beta$
Domain	$-\infty \leq x < +\infty$
VBA formula	= RndNormal (μ, σ [,α][,β])
μ	mean
σ	standard deviation
α	*optional, truncation left side, default value =* $-\infty$
β	*optional, truncation right side, default value =* $+\infty$
EV	mean value = μ

5.1.16 Pareto Distribution

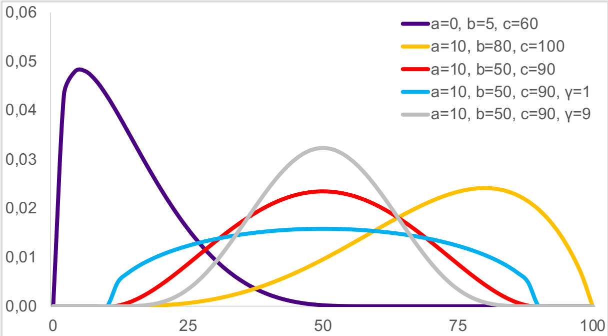
The Pareto distribution is used in description of social, quality control, scientific, geophysical, actuarial, and many other types of observable phenomena.



Parameters	$x_m > 0$, $\alpha > 0$
Domain	$x \geq 0$
VBA formula	= RndPareto (x_m, α)
x_m	scale parameter
α	shape parameter
EV	median value = $x_m \sqrt[\alpha]{2}$

5.1.17 PERT Distribution

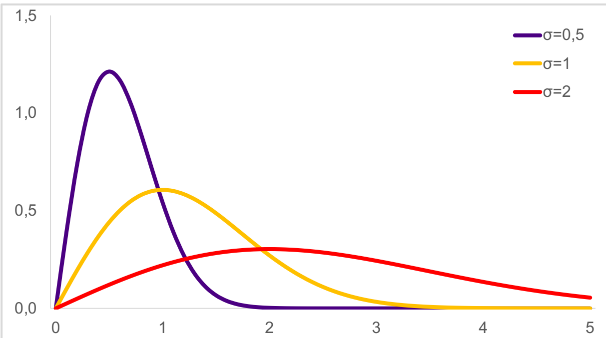
The (modified) PERT distribution is a version of the Beta distribution and requires the same three parameters as the Triangle distribution. It is used exclusively for modelling expert estimates and is a direct alternative to a Triangle distribution. The optional weight parameter for the standard PERT distribution is γ=4.



Parameters	min < mode < max, γ > 0
Domain	min ≤ x < max
VBA formula	= RndPERT (min, mode, max [,γ])
min	minimum
mode	most likely
max	maximum
γ	*optional, weight, default value = 4*
EV	mean value = $\frac{\text{min} + \gamma\ \text{mode} + \text{max}}{\gamma+2}$

5.1.18 Rayleigh Distribution

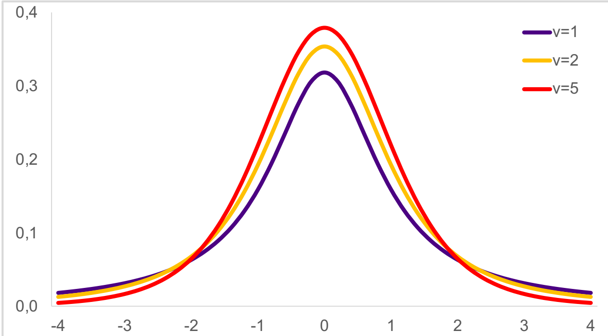
The Rayleigh distribution is frequently used to model hourly median and instantaneous peak power of received radio signals.



Parameters	σ > 0
Domain	x ≥ 0
VBA formula	= RndRayleigh (σ)
σ	scale parameter
EV	mean value = $\sigma\sqrt{\pi/2}$

5.1.19 Student-t Distribution

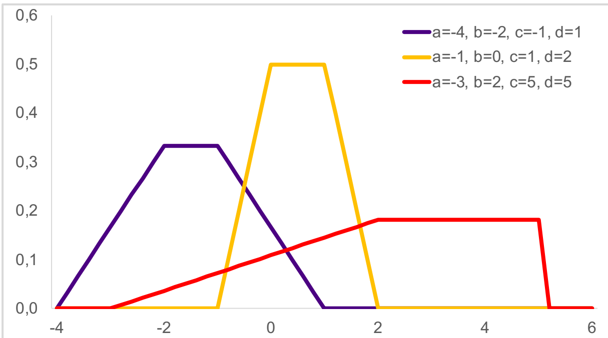
The Student-t distribution is used for the estimation of the mean of a (assumed normally distributed) population where random samples from that population have been observed, and its standard deviation is unknown.



Parameters	ν > 0, integer number
Domain	-∞ ≤ x < +∞
VBA formula	= RndStudentT (ν)
ν	degrees of freedom
EV	mean value = 0

5.1.20 Trapezoidal Distribution

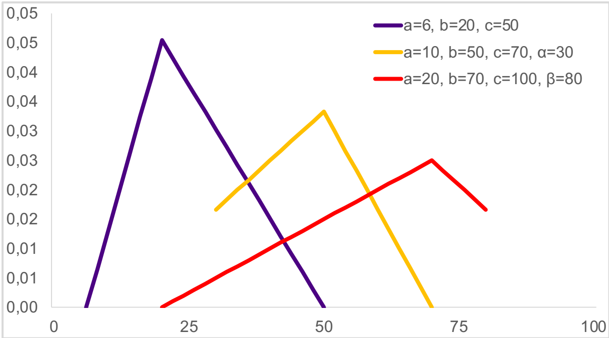
The Trapezoidal distribution is similar to the Triangular distribution but is used when there is not one single top but rather a longer distance with maximum probability values.



Parameters	a ≤ b ≤ c ≤ d
Domain	a ≤ x < d
VBA formula	= RndTrapezoidal (a, b, c, d)
a	lower bound
b	level start
c	level end
d	upper bound
EV	mean value = $\frac{1}{3\,(d+c-b-a)}\left(\frac{d^3-c^3}{d-c}-\frac{b^3-a^3}{b-a}\right)$

5.1.21 Triangular Distribution

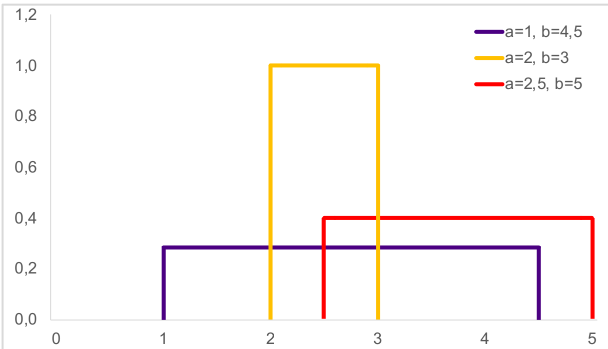
The Triangular distribution is typically used as a rough modelling tool when there is only limited sample data available. It is based on knowledge of minimum, maximum and a "best guess" for the modal value.



Parameters	min < max, min ≤ mode, mode ≤ max, α < β
Domain	min(α, min) ≤ x ≤ max(max, β)
VBA formula	= RndTriangular (min, mode, max [,α][,β])
min	lower bound
mode	most likely
max	upper bound
α	*optional, truncation left side, default value* = -∞
β	*optional, truncation right side, default value* = +∞
EV	mean value = $\frac{\text{min + mode + max}}{3}$

5.1.22 Uniform Distribution

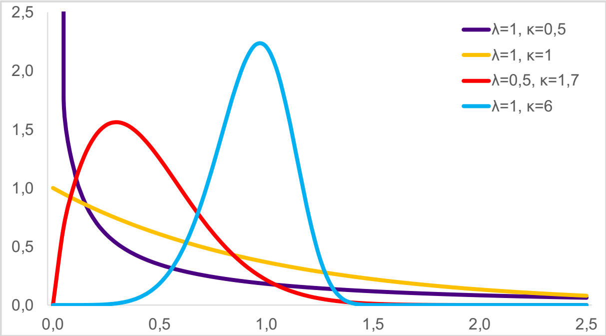
The Uniform distribution is typically used as a rough approximate model when there is very few or no data available.



Parameters	min < max
Domain	min ≤ x ≤ max
VBA formula	= RndUniform (min, max)
min	lower bound
max	upper bound
EV	mean value = $\frac{\text{min + max}}{2}$

5.1.23 Weibull Distribution

The Weibull distribution is often used in engineering to model the time until the occurrence of an event where the probability of occurrence changes over time.

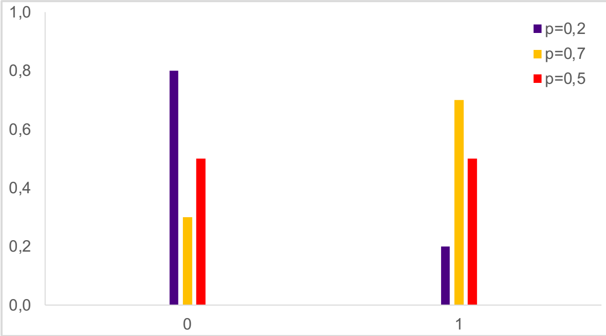


Parameters		$\lambda > 0, \quad \kappa > 0$
Domain		$x > 0$
VBA formula		= RndWeibull (κ, λ)
	λ	scale parameter
	κ	shape parameter
EV		mean value = $\lambda\Gamma\left(1+\frac{1}{\kappa}\right)$, where $\Gamma(z)$ = Gamma function = $(z-1)!$

5.2 Discrete Distributions

5.2.1 Bernoulli Distribution

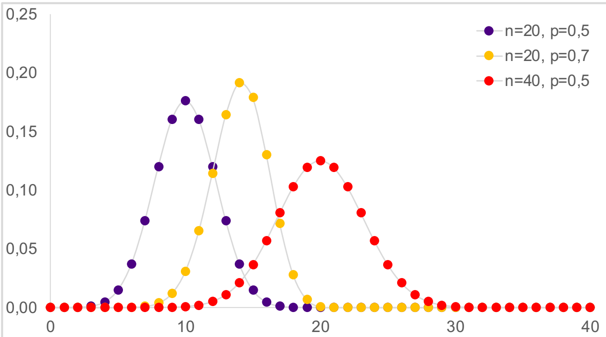
The Bernoulli distribution is used to model an event that may occur (i.e. taking the value 1) with a probability of *p* or may not occur (value 0).



Parameters	0 ≤ p ≤ 1
Domain	{0; 1}
VBA formula	= RndBernoulli (p)
p	probability of success
EV	mean value = p

5.2.2 Binomial Distribution

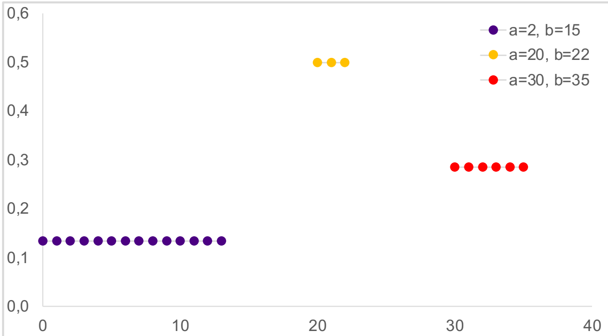
The Binomial distribution models the number of successes in a sequence of *n* independent experiments (with outcomes of 0 or 1) and constant probability *p* of success in each trial.



Parameters	n = {0; 1; 2;...}, 0 ≤ p ≤ 1
Domain	x = {0; 1; 2;... n}
VBA formula	= RndBinomial (n, p)
n	number of independent trials
p	probability of success
EV	mean value = np

5.2.3 Discrete Uniform Distribution

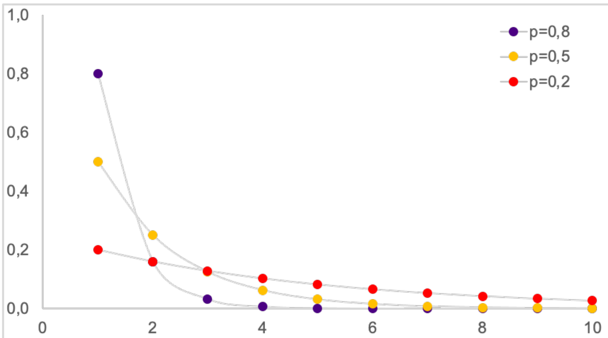
The Discrete Uniform distribution is a symmetric probability distribution wherein a finite number of values are equally likely to be observed; every one of n values has equal probability 1/n.



Parameters	min = {0; 1; 2;...}, max = {0; 1; 2;...}
Domain	x = {min ... max}
VBA formula	= RndDiscUniform (min, max)
min	lower bound
max	upper bound
EV	mean value = $\frac{min + max}{2}$

5.2.4 Geometric Distribution

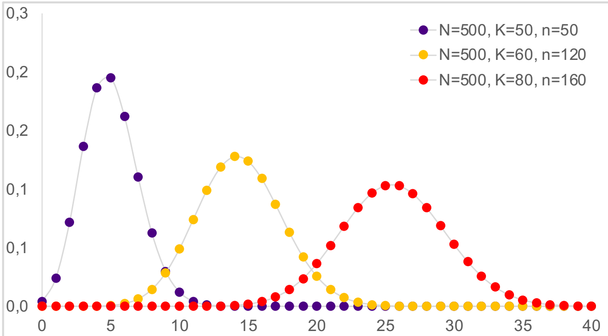
The Geometric distribution models the number of failures that will occur before the first success in a set of binomial trials, given that *p* is the probability of a trial succeeding.



Parameters	$0 < p \leq 1$
Domain	x = {1; 2; 3;...}
VBA formula	= RndGeometric (p)
p	probability of success
EV	mean value = $^1/_p$

5.2.5 Hypergeometric Distribution

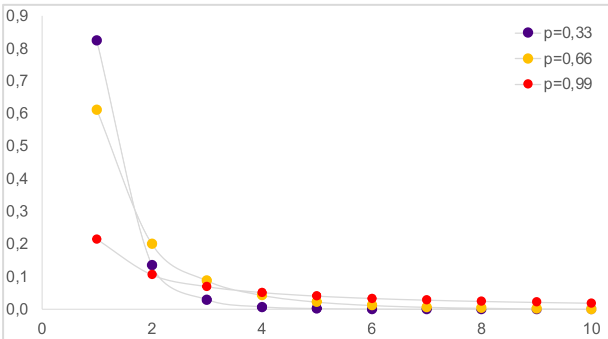
The Hypergeometric distribution models the number of items of a particular type that there will be in a sample of size *n* where that sample is drawn from a population of size *N* of which *K* are of that particular type.



Parameters	0 < n ≤ N, 0 < K ≤ N, N > 0, N, K, n are integer numbers
Domain	max(0, n+K-N) ≤ x ≤ min(n, K)
VBA formula	= RndHypergeometric (N, K, n)
N	population size
K	number of success objects in the population
n	number of draws (i.e. quantity drawn in each trial)
EV	mean value = $n\frac{K}{N}$

5.2.6 Logarithmic Distribution

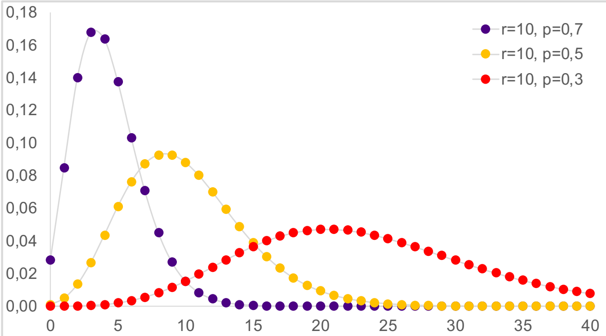
The Logarithmic distribution has a peak at x = 1 and a long right tail. It is quite popular in the insurance industry for modelling claim frequency.



Parameters	0 < p < 1
Domain	x = {1; 2; 3; …}
VBA formula	= RndLogarithmic (p)
p	probability of success
EV	mean value = $\frac{-1}{\ln(1-p)}\frac{p}{(1-p)}$

5.2.7 Negative Binomial Distribution

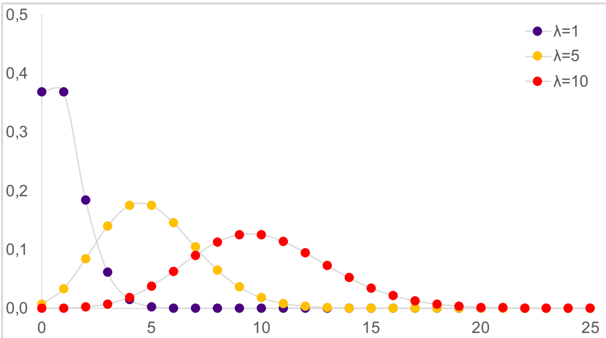
The Negative Binomial distribution estimates the number of failures in a sequence of independent and identically distributed Bernoulli trials before a specified number of successes (r) are achieved, where there is a probability of success (p) with each trial.



Parameters	r > 0, 0 < p ≤ 1, n is an integer number
Domain	x = {0; 1; 2; ...}
VBA formula	= RndNegBinomial (r, p)
r	number of successes
p	probability of success
EV	mean value = $\frac{n(1-p)}{p}$

5.2.8 Poisson Distribution

The Poisson distribution estimates the occurrence of events following a Poisson process. It is used for example to simulate the number of customers arriving at a counter or the number of losses or claims occurring in a given period of time.



Parameters	λ > 0
Domain	x = {0; 1; 2; ...}
VBA formula	= RndPoisson (λ)
λ	expected rate of occurrences
EV	mean value = λ

6 Technical Details

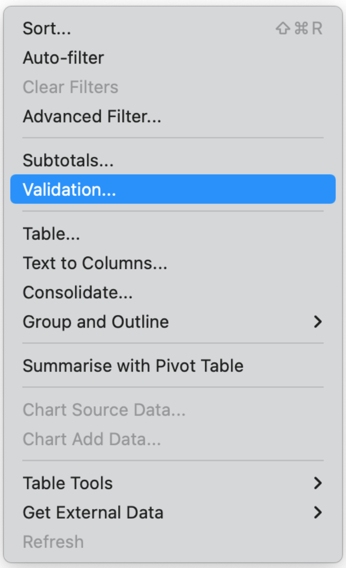
6.1 Designed and Developed for macOS, fully functional on Windows

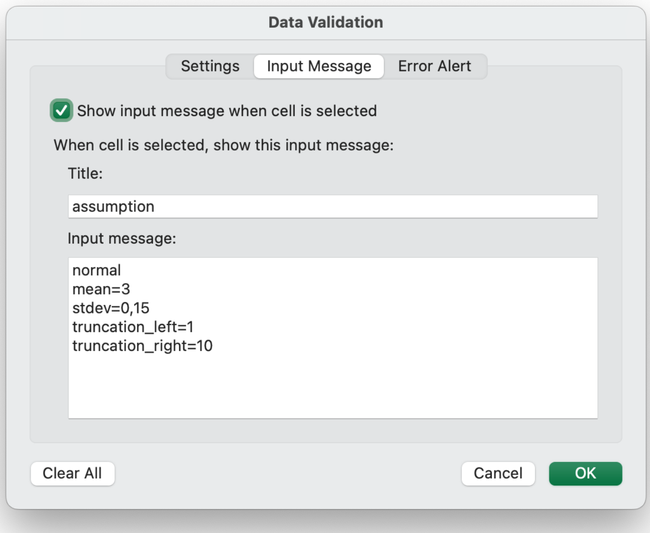
Microsoft has launched its Office applications including Excel for macOS some years ago. Unfortunately, the calculation speed and functionality of macOS versions lack far behind the Windows applications. Calculations take several times longer and many features of the Windows versions are implemented on macOS either not properly or not at all.

We therefore have developed the add-in specifically to run on macOS devices and considered all restrictions of the macOS Excel environment. As Windows versions are more mature developed, there should not be any problems in running the add-in on Windows devices due to upward compatibility.

6.2 Stored Parameter Information

All parameters to define Assumptions, Observations or Forecasts are stored in a transparent way in the Excel spreadsheet. The additional information is saved in the input message field of the data validation for cells. This data can be accessed in Excel directly via the menu Data / Validation.





Assumptions are marked with a short name for the distribution, followed by the parameters of the probability distribution. Observations are specified just with the title "observation" and and Forecasts are marked with the title "forecast", followed by parameters that define the histogram chart layout.

All definitions could be accesses and changed directly by the user, but it is not recommended to do that because several error checking routines are skipped. It is important to know that the input message fields are required by eniacSim and therefore cannot be used otherwise.

6.3 Developing your Custom VBA Application

eniacSim uses specific VBA macros to define parameters, run a simulation and draw charts with the simulation results. Users can directly access these macros when developing their own applications. All parameters in the functions are optional. If no arguments are handed over, default values are used.

6.3.1 reset(message)

VBA sub	reset (message)		
Sub	Resets/clears all simulation data		
Parameters	Name	Data type	Description
	message	boolean	If true, a message box opens and asks if all data shall be cleared. If user presses Cancel, no data is cleared. If false, no message box is opened and all data is cleared without warning. Default value is true.
Examples	Reset(true) Reset(false)		Opens a popup window and asks if all simulation data shall be deleted. Clears all simulation data without query.

6.3.2 simulation(iterations)

VBA sub	simulation (iterations)		
Function	Starts a simulation with the number of iterations. If simulation results exist already, new results will be saved on top of existing results.		
Parameters	Name	Data type	Description
	iterations	long integer	Iterations can be up to a total of 1 million. Default value is 100.
Examples	simulation() simulation(5000)		Runs 100 (additional) simulation iterations Runs 3.000 (additional) simulation iterations

6.3.3 sensitivity()

VBA sub	sub sensitivity()		
Function	Performs a sensitivity analysis and draws the V-shaped sensitivity chart(s).		
Example	sensitivity()		Runs a sensitivity analysis and draws the charts for each Forecast.

6.3.4 tornado(sensitivity)

VBA sub	sub tornado (sensitivity)		
Function	Performs an OFAT analysis and draws the tornado chart(s).		
Parameters	Name	Data type	Description
	sensitivity	integer	Number of sensitivity steps between 3 and 25. Default value is 3.
Examples	tornado()		Runs an OFAT analysis with sensitivity of 3% for all parameters (Assumptions and Observations) and draws the tornado charts for each Forecast.
	tornado(5)		Runs an OFAT analysis with a sensitivity of 5%.

6.3.5 Random Distribution Functions

All functions to generate random numbers can be accessed by the user. A detailed description of all random functions is listed in chapter 5.