UNIVERSITÀ DEGLI STUDI DI BERGAMO
Dipartimento di Ingegneria Gestionale, dell'Informazione e della Produzione

# 22059 – APPLIED TOPICS IN MANAGEMENT ENGINEERING

## Excel, Access and Matlab

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# AGENDA

## Lecture v

- FUNCTIONS TO GENERATE RANDOM NUMBERS
  - RAND
  - RANDBETWEEN
- MONTE CARLO SIMULATION
  - How to implement in Excel
  - Data Analysis
- FURTHER MATERIAL

# RAND (CASUALE)

- The RAND function generates a random decimal number between 0 and 1 evenly distributed.
- RAND recalculates when a worksheet is opened or changed.

RAND ()

- The function has not any argument.

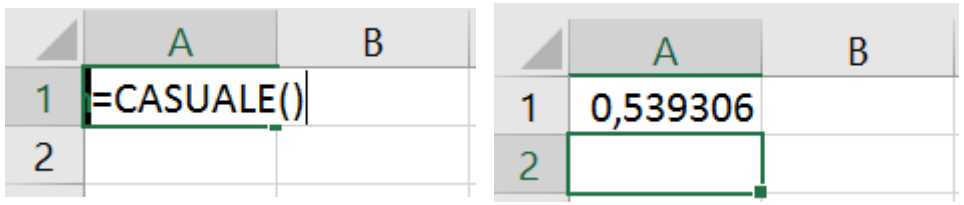


**Fig.1**: Example of RAND ()

- In order to generate a list of random numbers, you have to drag the formula down.
- If you want the calculated value not to change:

1. Copy the cell with random number (or list).
2. Paste it as values.

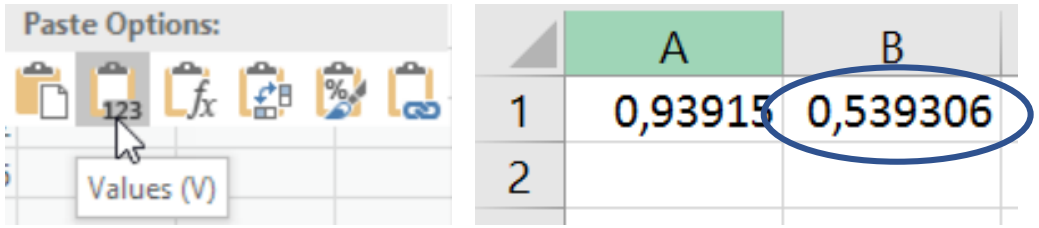


**Fig.2**: Example

Now, the initial random number is a value, but in cell A1 the random number has changed.

# RANDBETWEEN (CASUALE.TRA)

- The RANDBETWEEN function generates a random whole number between two boundaries.

RANDBETWEEN (bottom,top)

- bottom: The lowest value allowed.
- top: The highest value allowed.

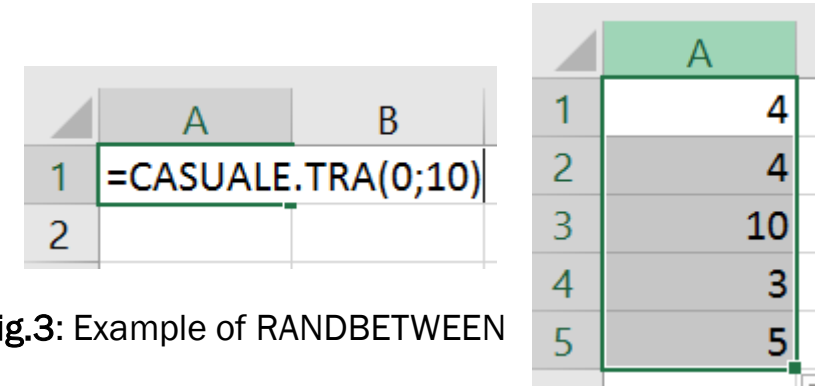


**Fig.3**: Example of RANDBETWEEN

- To generate a decimal random number between two numbers, you have to modify the RAND function as follow:

RAND()*(b-a)+a

Ex. Random decimal number between 50 e 75 →

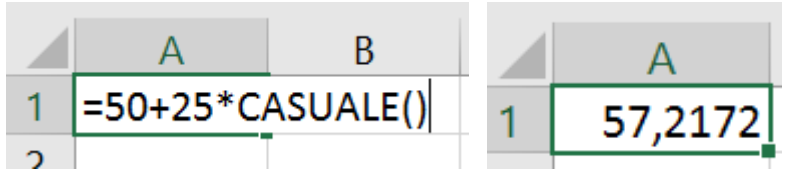


**Fig.4**: Example of RAND with decimal numbers

# MONTE CARLO SIMULATION

- Monte Carlo Simulation allows to model the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables.

It is used to:

  - Assessing the impact of risk, allowing for better decision making under uncertainty.
  - Performing risk analysis by building models of possible results by substituting a probability distribution for any factor that has inherent uncertainty.
  - This technique is used in several fields such as finance, project management, manufacturing, transportation etc.

- Monte Carlo Simulation does not provide a specific result, but a distribution of possible outcomes.

# How to implement in Excel

- First, you decide the type of distribution and the number of iterations.

[In the following example, a normal distribution and 1000 iterations will be considered]

## STEP 1

A normal distribution is characterized by two variables:

- Mean
- Standard deviation

## INPUT VARIABLES:

| | A | B |
|---|---|---|
| 1 | | **Case 1** |
| 2 | **Mean** | 100 |
| 3 | **Std_deviation** | 40 |
| 4 | **Iterations** | 1000 |

**Fig.5**: Initial data

# MONTE CARLO SIMULATION - How to implement in Excel

- To calculate the “Value X” of a normal distribution with defined mean and standard deviation, you have to use:

## STEP 2

NORM.INV(probability,mean, std_deviation)
INV.NORM(probabilità; media; dev_standard)

- Probability → The function RAND() to elicit a random number based on the other criteria within the distribution.
- Mean → The mean defined in STEP 1.
- Standard deviation → The standard deviation defined in STEP 1.


**Fig.6**: How to calculate Value X

# MONTE CARLO SIMULATION - How to implement in Excel

- Now, to automatically implement the Monte Carlo Simulation, you have to use a Data Table (for more details, see Lecture I):

| Simulation |
|---|
| 1 |
| 2 |
| 3 |
| 4 |
| 5 |
| 6 |
| 7 |
| 8 |
| 9 |
| 10 |
| 997 |
| 998 |
| 999 |
| 1000 |

| | | |
|---|---|---|
| 6 | | Case 1 |
| 7 | Value X | 115,4804 |
| 8 | | |
| 9 | Simulation | =B7 |
| 10 | 1 | |

| Simulation | 115,4804 |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |
| 11 | |
| 12 | |
| 13 | |

**Fig.7**: Data Table preparation steps

## STEP 3

After performing the primary steps, in order to run the Monte Carlo Simulation you have to select an empty cell in the box «column input cell» (see Figure 8).

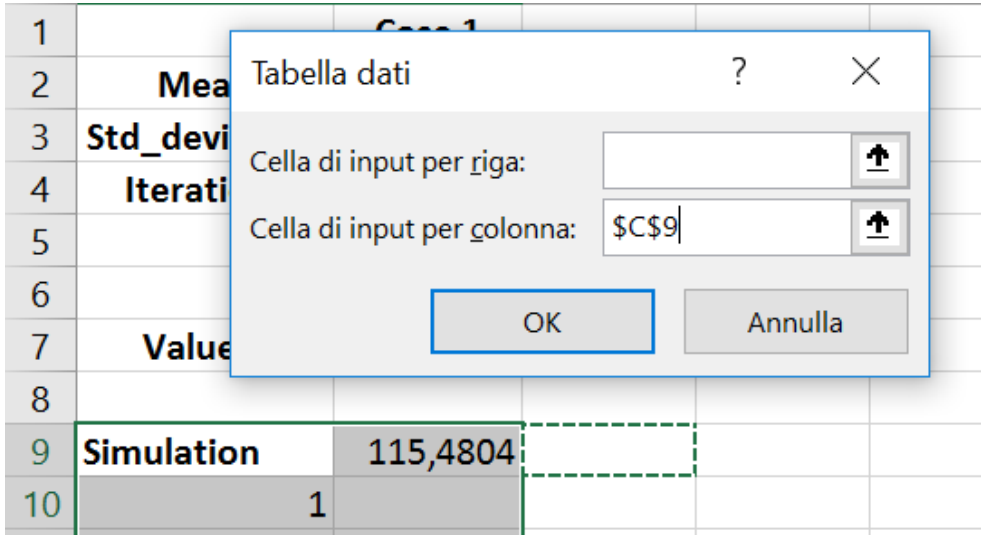


**Fig.8**: Empty cell selection

| | | |
|---|---|---|
| 9 | **Simulation** | 115,4804 |
| 10 | 1 | 100,0503 |
| 11 | 2 | 198,6664 |
| 12 | 3 | 18,75203 |
| 13 | 4 | 45,35186 |
| 14 | 5 | 133,2154 |
| 15 | 6 | 112,0618 |
| 16 | 7 | 147,8382 |
| 17 | 8 | 67,1604 |
| 18 | 9 | 129,9201 |
| 19 | 10 | 116,8338 |

**Fig.9**: Monte Carlo Simulation

# MONTE CARLO SIMULATION - How to implement in Excel

- Monte Carlo Simulation has been run.
- To perform a detailed analysis on the obtained distribution, you have to activate the “Data Analysis” Tab.

**How?**

- Click on File → options
- Select “Componenti aggiuntivi”
- Click on “Vai…”
- Select “Strumenti di analisi”
- Click on OK

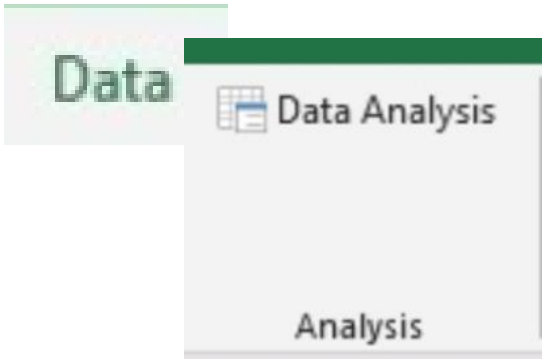


**Fig.11**: «Data Analysis» in Data Tab

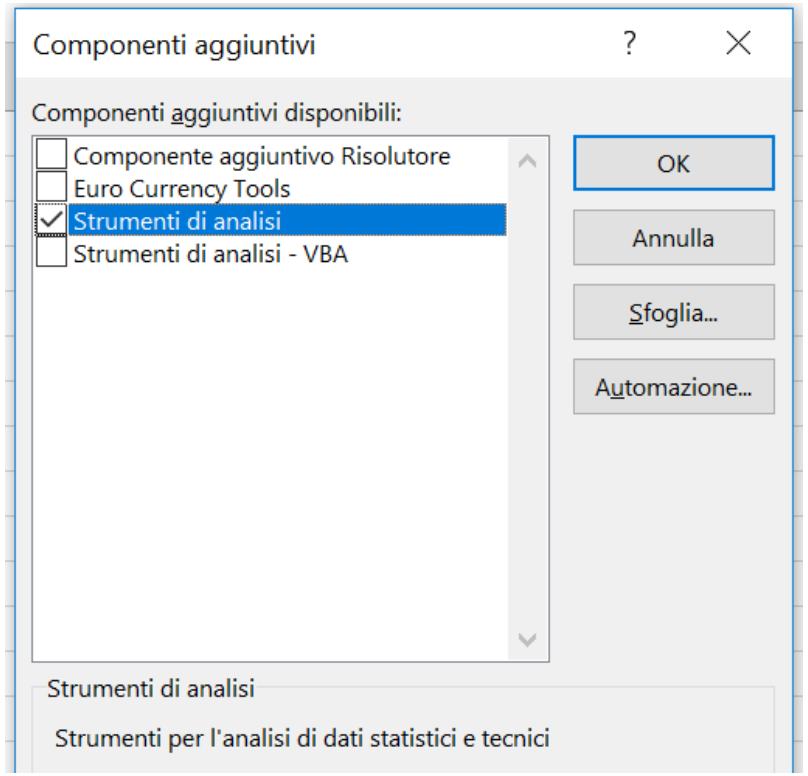


**Fig.10**: «Strumenti di analisi» selection

# Data Analysis

- To generate a histogram of the Monte Carlo Simulation outcomes, you have to:
  - Click on Data Analysis Tab
  - A “Data Analysis” window will appear
  - Select “Histogram”

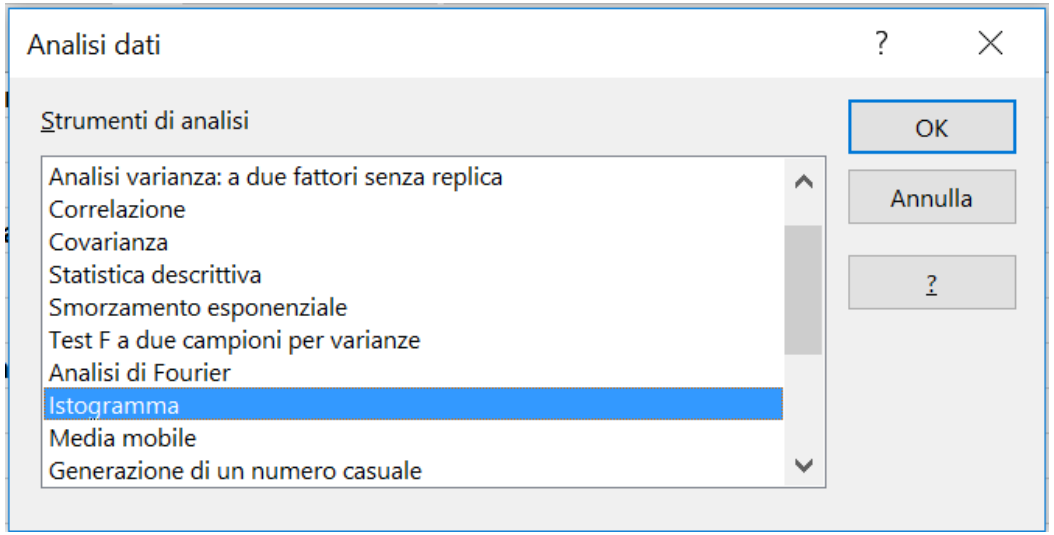


**Fig.12**: «Histogram» selection

## MONTE CARLO SIMULATION - Data Analysis

- To generate a histogram of the Monte Carlo Simulation outcomes, you have to:
  - Insert “input range” (cells range with simulation outcomes).
  - Define “Output options”
  - Choose which output you want to get

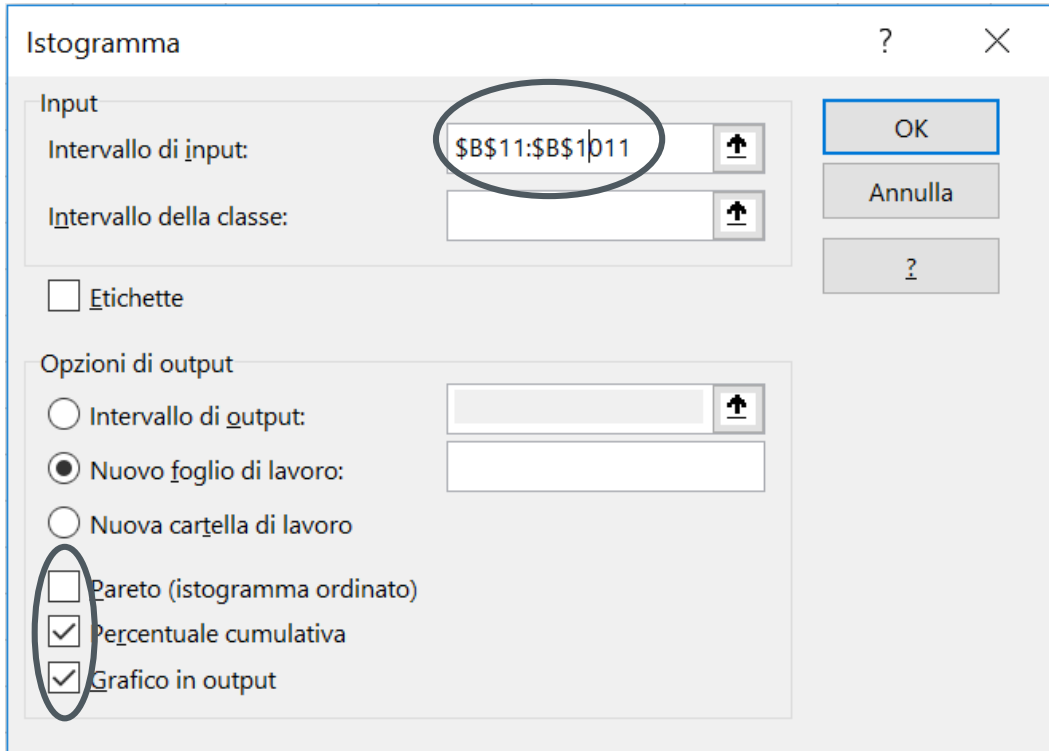


**Fig.13**: Histogram input and output

# MONTE CARLO SIMULATION - Data Analysis

- After a short period of time the histogram will appear:

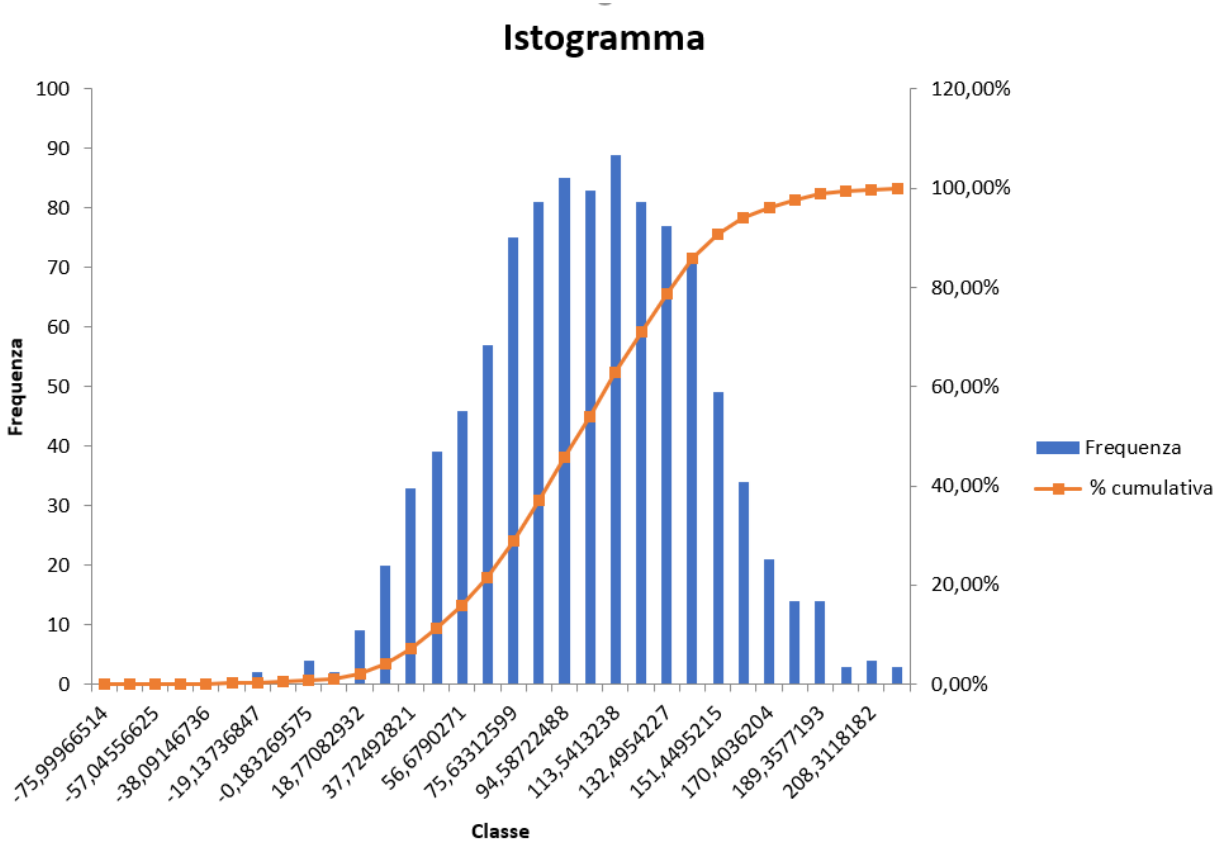


**Fig.14**: Histogram with frequency and cumulated probability

# MONTE CARLO SIMULATION - Data Analysis

- If you want to know in detail the characteristics of the results distribution you have to:
  - Click on Data Analysis Tab
  - A “Data Analysis” window will appear
  - Select “Statistica descrittiva”

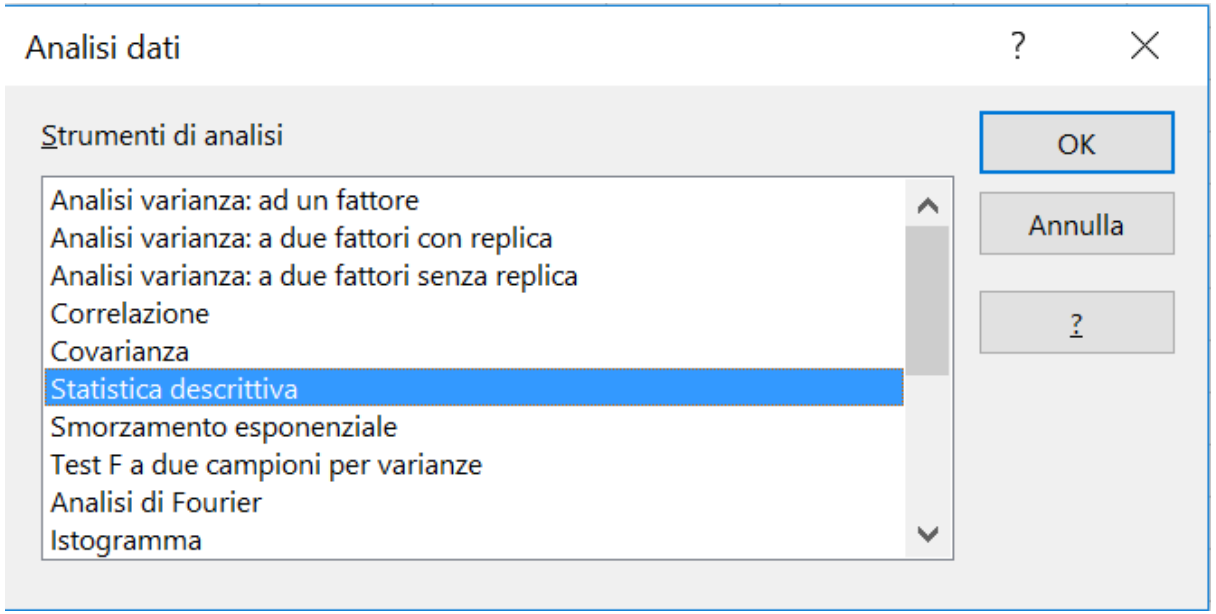


Fig.15: «Descriptive statistics» selection

## MONTE CARLO SIMULATION - Data Analysis

- To generate the Descriptive Statistics of the Monte Carlo Simulation outcomes, you have to:
  - Insert “input range” (cells range with simulation outcomes).
  - Define “Output options”
  - Choose which output you want to get

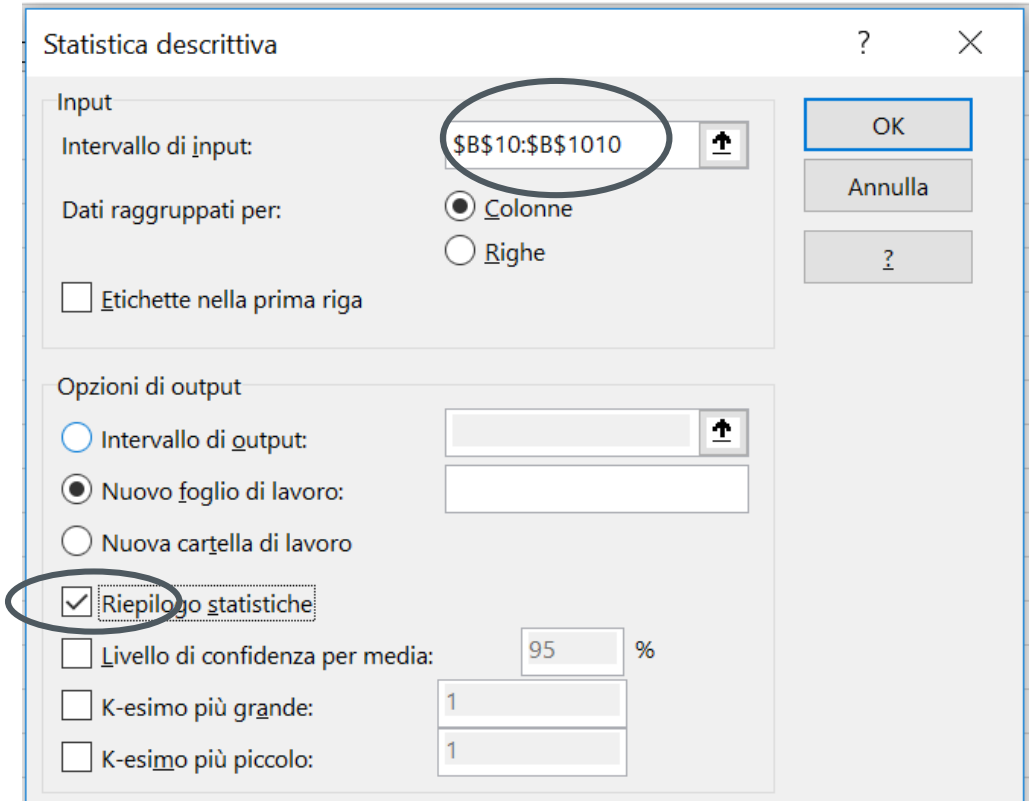


**Fig.16**: «Descriptive statistics» input and output

# MONTE CARLO SIMULATION - Data Analysis

- After a short period of time, Descriptive Statistics will appear:

| | A | B |
|---|---|---|
| 1 | *Colonna1* | |
| 2 | | |
| 3 | Media | 98,57618941 |
| 4 | Errore standard | 1,300445695 |
| 5 | Mediana | 99,65623932 |
| 6 | Moda | #N/D |
| 7 | Deviazione standard | 41,12370371 |
| 8 | Varianza campionaria | 1691,159006 |
| 9 | Curtosi | 0,067007798 |
| 10 | Asimmetria | -0,096766768 |
| 11 | Intervallo | 293,7885328 |
| 12 | Minimo | -75,99966514 |
| 13 | Massimo | 217,7888677 |
| 14 | Somma | 98576,18941 |
| 15 | Conteggio | 1000 |

Fig.17: «Descriptive statistics»

- Obviously, some parameters could have been calculated with excel formulas:
  - Average → AVERAGE ()
  - Median → MEDIAN ()
  - Maximum → MAX ()
  - Minimum → MIN ()
  - Sum → SUM ()
  - Count → COUNT ()
  - Standard Deviation → STDEV ()

# FURTHER MATERIAL

To review and deepen the topics of this lecture

1. https://www.youtube.com/watch?v=HwVBi--mE4M

2. Alexander, M., Kusleika, R., & Walkenbach, J. (2018). Excel 2019 Bible. John Wiley & Sons