The MS Word Equation Editor

Preamble

In Data Analytics, statistics and GISciences equations are used to express in a compact way how data are processed to obtain a desired results. The equations and their associated symbols are then ***transcribed into computer algorithms***, which do the actual work of manipulating the data into information. Both equations and computer algorithms can be considered specialized languages. As professional data analysts, we need to be familiar with these languages to communicate efficiently with our peers and morph problems into solutions by reading and writing equations and computer algorithms.

Overview

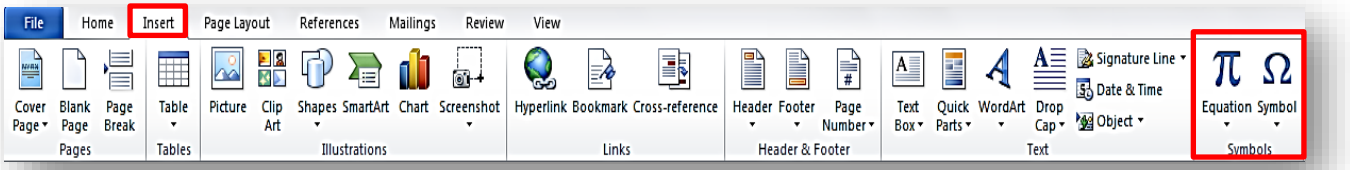
This tutorial gives a basic introduction to typesetting of mathematical equations in Microsoft Word. Throughout your graduate training you are required to add professionally typeset equations to your term papers and presentations. Warning: scanning equations and pasting them into your document is not acceptable. If you have several equations in your documents, then you need to develop [a] a *consistent nomenclature* (system of mathematical symbols) and [b] *define* each term and symbol.

There are several professional typesetting tools available. We will focus only on the embedded editor that comes with MicroSoft **WORD**. Note that this editor has minor problems with **POWERPOINT**. The more elegant and powerful add-on Word equation editor is **MATHTYPE** can be bought from *Design Science* (http://www.dessci.com/en/).
Academic publishing houses and professional journals may use also the open-source system **LATEX**., which can be integrated with  using the development environment  (see Lander *Chapter 23:*

Reproducibility, Reports and Slide Shows with `knitr` or Kabacoff *Chapter 22: Creating dynamic reports*). In addition, RStudio also supports the less powerful Markdown, which integrates text, R code and output.

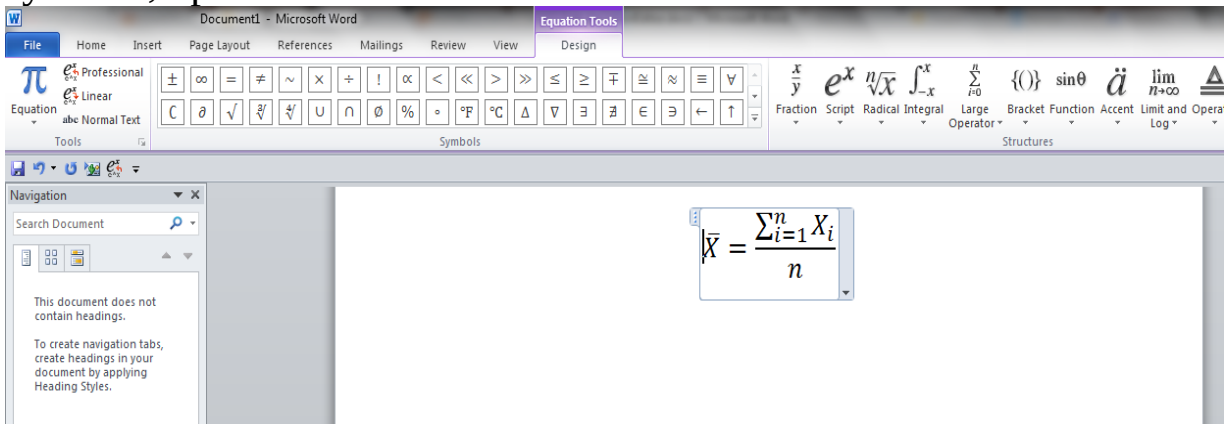
Accessing Microsoft's Built-In Editor

It is a "BUILT-IN" editor and comes as part of the Microsoft Office installation. It is available in the **INSERT** Tab under the **SYMBOLS** section



Workflow:

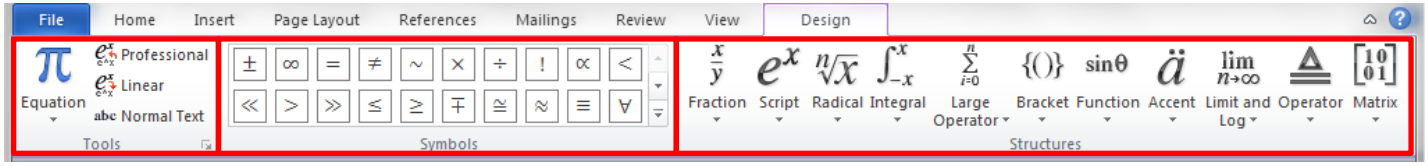
- Place the cursor in your document at the position or empty line where an equation needs to be inserted.
- Click **INSERT→ EQUATION** or alternatively use the shortcut "**ALT**" + "**=**"
- Insert the equation inside the rectangular equation editor box by either typing or clicking on the symbols, operators and characters from the **DESIGN** tab.



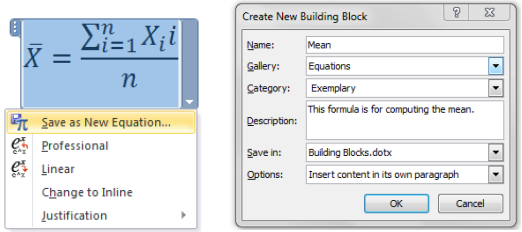
- To close the equation editor, click outside the editing box. To re-edit an equation, click anywhere inside the equation. This will display the equation editing box and reopens the **DESIGN** Tab.
- Complete equations or fragments of them can be copied/cut and pasted into different parts of the document or into different documents. Doing so will create another equation box at the pasted location.
- To increase the size of the equation, select the equation, go to **HOME** tab while in the equation editing box and select the font size in the **FONT** section.
  Alternatively use the keyboard shortcut of CTRL+] for increasing and CTRL+[for decreasing the font size.

Key Organization of the Equation Editor

The **DESIGN** tab has *three sections*: **TOOLS**, **SYMBOLS** and **STRUCTURES**



1. TOOLS (left): This section provides access to the equation gallery of stored equations such as area of circle, binomial theorem, Fourier series etc. You can also save our own equations into the gallery for later re-use by clicking the down symbol ▼ in the equation box and select **SAVE AS NEW EQUATION**



In the **CREATE NEW BUILDING BLOCK** dialog box, enter a name and short description for the equation and select OK. This equation is now ready to be used in all Word documents from Equation Gallery.

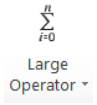
Another option in the **TOOLS** section is the text modes. Three basic modes are available:

- Normal Text: This mode enters non-mathematical text within an equation.
- Professional Format: This is the mode for writing the equations in **DISPLAY** format, i.e., equations that are written independently and separately from the regular text in their own line centered in-between the margins. These equations may be numbered at the right margin so one can refer to the equation in the text by its number (see appendix).
  For example:
  The mean of a population with N members is:
  $$\mu = \frac{1}{N} \cdot \sum_{i=1}^{N} X_i$$
  Notice the placement of the subscript and superscript below and above the summation symbol Σ.
- Linear Format: This is the mode for writing **INLINE** equations, i.e., equations are embedded in a regular line to text. For example:
  The mean of a population with N members can be represented by $\mu = \frac{1}{N} \cdot \sum_{i=1}^{N} X_i$ *within your text.*
  Notice the space-saving placement of the subscript and superscript behind the summation symbol and the smaller font of the fraction.
  Individual symbols in the text should be entered using the equation editor and not as plain text because the formatting of mathematical symbols usually differs. For instance, the population size N is set in *italics* and not as upright N.

2. SYMBOLS (middle): This section contains the commonly used mathematical *symbols*. By default it displays the **BASIC MATH** symbols. Other symbol palettes can be reached in several drop-down sub-menus:

Note: Mathematicians and statistician like to use Greek letters and other fancy symbols. It is helpful to learn some of these commonly used symbols.

3. STRUCTURES (right): The structures contain the formatting *templates* for creating equations such as brackets, summation operators, matrix structure etc. Each major structure is given as a drop down menu with more custom options under each. Structures come with blank infill boxes into which you can insert indices, terms and symbols etc. Frequently you need to nest several *templates* to create an equation.

Example: The *summation* icon 

opens a place-holders in the display-style. Placeholders here are for super- and sub-scripts as well as the term to be summed up.

Example: Built-in probability *function* with place holder of the random variable, i.e., $\Pr[\square]$.
Note: Type 'Pr' in the equation insert mode and then a space. Notice that the italic '*Pr*' changes to the upright representation 'Pr' with the placeholder $\square$.

Example: Auto-scaling brackets {()} Bracket nested into the probability function, i.e., $\Pr[\square]$. Auto-scaling brackets adjust their size in dependence of the vertical extend of symbols within them, e.g., $\Pr\left[\frac{1}{X}<5\right]$.

Example: Super- and subscripts e^{x} Script added to a highlighted symbol σ, i.e., $\sigma_{\square}^{\square}$ becomes σ_X^2

Follow the Logical Structure of Equations

In order to typeset an equation it is important to understand its ***internal structure***. By typesetting equations you will understand the interplay and structure of its associated terms. The nested sequence of templates is important; very much like in any programming language where the proper sequence of instructions is important. One needs to follow the ***nested hierarchy*** that exists in an equation from its most general outer structure to its specific internal terms. Equations very much follow the structure of *Russian Matryoshka* dolls and are built from the outside towards the inside.
For example, consider the equation for sample standard deviation,

$$s=\sqrt{\frac{\sum_{i=1}^{n}\left(X_i-\bar{X}\right)^2}{n-1}}\,.$$

1. The term right of the equal sign it can be broken down into the all-encompassing square root $\sqrt{\square}$,
2. This encloses the ratio of a numerator and a denominator $\frac{\square}{\square}$.
3. The numerator is defined by a summation template $\sum_{\square}^{\square}\square$.
4. Now you enter the super-script template and $\square^{\square}$. Into the superscript you place the 2 for squaring its baseline expression
5. In the baseline expression you insert the parentheses tool $(\square)$, which scales the size of the parentheses dynamically according to the height of its content.
6. The difference $X_i - \bar{X}$ goes in-between the parenthesis. Note that the subscript i is used for X and a decorative bar $\overline{\square}$ is added onto of X to denote the sample mean $\bar{X}$.
   Now you type-set the term $(X_i - \bar{X})^2$ within the summation template.
7. Add the subscript for starting index $i = 1$ and the superscript n to complete the summation template.
8. The denominator term is a simple difference $n - 1$.

If one violates the nested structure of an equation, the equation may lack professional appearance and can become quite confusing or even incorrect to an uninformed reader. Please see the example below

$$s = \frac{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})}^2}{n-1},$$

Does the square apply to the summation of the difference from the mean? Is the denominator underneath the square-root?

Type-setting Templates

1. Subscripts and superscripts: These are the most commonly encountered forms of typesetting. Typeset a variable X with both subscript and superscript: X_i^2

Hints:

- Highlight the character or symbol to which the subscript/superscript is applied. Alternatively, use an empty script template and fill it in.
- Select **SCRIPT** options in the **STRUCTURES** section and select the appropriate structure.
- A set of common scripts and subscripts templates are provided that can be added and edited as needed.

2. Summation and Product: Try entering summation and product of n elements of X as display equations given by:

$$\sum_{i=1}^{n} X_i \quad \text{or} \quad \prod_{i=1}^{n} X_i$$

And as inline equations where the summation is displayed as $\sum_{i=1}^{n} X_i$ or $\prod_{i=1}^{n} X_i$. Note that the "or" is formatted within the display equation as "normal text".

Hint: Once the display equation is typeset, copy it and place it at the inline location. Word will automatically convert it from the display format to the inline format.

3. Divisions: Display the 95%-confidence interval, e.g., the lower and upper bound, around the population mean as an inline equation given by $\mu \pm 1.96 \cdot \sigma/\sqrt{n}$ or in the display format:

$$\mu \pm 1.96 \cdot \frac{\sigma}{\sqrt{n}}$$

Note: the multiplication dot can be found in the standard symbols palette.

4. Growing Brackets: Brackets, once placed, can grow along with the text being entered inside them.
Typeset the following fraction:

$$\left(\frac{1}{2+\frac{3}{4+\frac{5}{6+\frac{7}{8+\frac{9}{10}}}}}\right)$$

Hint: Break down the fraction into parts and keep growing it and watch the bracket growing along with it.
Alternatively, type 1/(2+3/(4+5/(6+7/(8+9/10)))) inside the equation editor and hit the space bar.

5. Matrices: Matrix of any size and structure can be entered using the matrix templates.
Enter the following matrix **A** and its transpose:

$$\mathbf{A} = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \end{bmatrix}$$

$$\mathbf{A}^T = \begin{bmatrix} 1 & 5 & 9 \\ 2 & 6 & 10 \\ 3 & 7 & 11 \\ 4 & 8 & 12 \end{bmatrix}$$

Note: Matrices are always denoted by ***bold capital non-italics*** letters. You thus need to change this manually by changing their font properties.
Hint: Use the **STRUCTURE** option to enter the basic matrix structure. Add/Delete more rows and columns by right-clicking inside the matrix which opens a pop-up menu. Spacings can also be adjusted this way.

6. Definition of piecewise functions: Typeset the following uniform continuous random variable:

$$f(x) = \begin{cases} \frac{1}{10} & 0 \leq x \leq 10 \\ 0 & \text{otherwise} \end{cases}$$

Hint: First type the function symbol $f(x) =$ and bracket $\{\square$. Place the rest of the equation inside a 2x2 matrix $\begin{matrix} \square & \square \\ \square & \square \end{matrix}$ and adjust the matrix spacing by right-clicking into it and selecting the proper options.

7. Lining up multi-line equations:

$$\begin{aligned} s^2 &= \frac{1}{n-1} \cdot \sum_{i=1}^{n} (X_i - \bar{X})^2 \\ &= \frac{1}{n-1} \cdot \sum_{i=1}^{n} X_i^2 - \bar{X}^2 \end{aligned}$$

Hint: Typeset both equations separately and highlight both equations with the mouse. Right-click into the highlighted section and select “Align at =”.

8. Using under-brackets:

$$\underbrace{\sum_{i=1}^{n} X_i}_{=n \cdot \bar{X}}$$

You can find the under-bracket template in the Accent structure.

Appendix 1: Adding Numbered Display Equations (not course relevant)

The display equations in a document can be sequentially numbered. This allows an author to refer to individual equations by number. See for example:

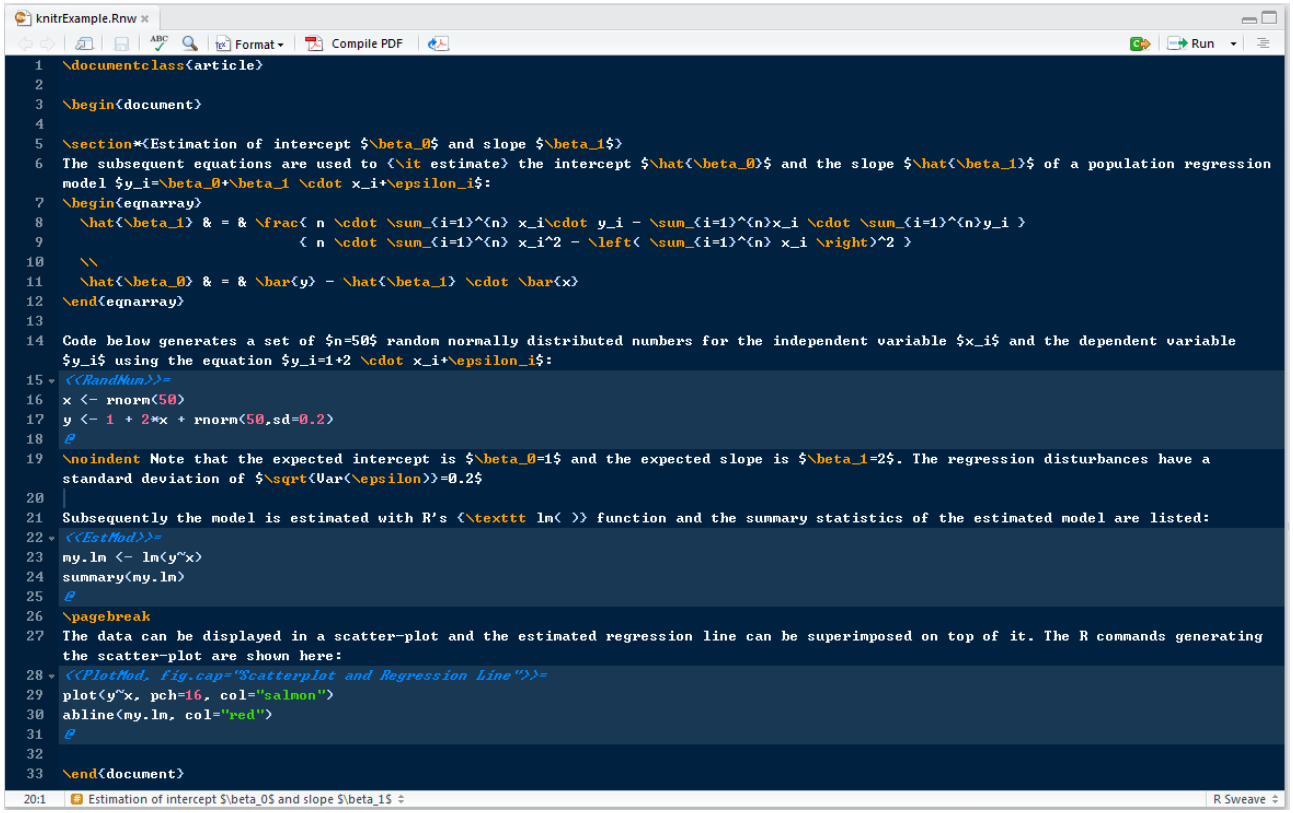
> The arithmetic mean of a set of n observations $\{x_1, x_2, \ldots, x_n\}$ is defined as
>
> $$\bar{x} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i \,. \tag{1}$$
>
> The conceptional formula for the empirical variance is
>
> $$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1} \,. \tag{2}$$
>
> It requires that the arithmetic mean in eq. 1 is already available. Note that there is an alternative but equivalent way of writing the expression of the variances in eq. 2, which has computational advantages.

Unfortunately, Word does not provide a ready-made template for numbered display equations and one needs to implement these oneself. Guidelines can be found at the link http://superuser.com/questions/594559/how-do-you-easily-add-equation-numbers-to-microsoft-word-2010-equations .

Appendix 2: Using `knitr` in RStudio (not course relevant)

Lander *Chapter 23: Reproducibility, Reports and Slide Shows with* `knitr` provides a brief introduction how to integrate within RStudio the type-setting system LaTeX and R commands.

An example for estimating a regression model and documenting the results is given in the document **`knitrExample.Rnw`**. You can open this document in a RStudio editor window with File ▶ Open File …



Make sure that the **knitr** library is available to R and the LaTeX system is installed on your computer. Select Compile PDF to view this document as compiled pdf-file.