From \begin to \end

The Complete LaTeX Guide

Day 2 of 7 — Math Mode for Economists

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Format:	7-Day Intensive Course
Session:	Day 2 of 7

Today's Agenda

1. Recap & Today's Goal
2. Math Mode Basics
3. Subscripts, Superscripts & Notation
4. Fractions & Multi-line Derivations
5. Matrices
6. Numbering & Referencing Equations
7. Practice

Quick Recap: Day 1

Last day you learned document anatomy: preamble vs. body, `\documentclass`, `\usepackage`, the title block, sections, paragraphs, bold/italic text, and how to read your first compile errors.

Today's goal: equations are the single biggest reason economists switch to LaTeX. By the end of today you will typeset models, regression specifications, and notation with full precision – no equation editor required.

Inline vs. Display Math

```
The elasticity is $\varepsilon = \frac{dQ}{dP}\cdot\frac{P}{Q}$.

\begin{equation}
  \pi = TR - TC
\end{equation}
```

Compiled Output

The elasticity is $\varepsilon = \frac{dQ}{dP} \cdot \frac{P}{Q}$.

$$\pi = TR - TC \tag{1}$$

Why & What: `$...$` is **inline** math – it flows inside a line of text, like the elasticity formula above. The `equation` environment is **display** math – it's centered on its own line and, unlike `\[...\]`, is **automatically numbered**, which matters once you start cross-referencing equations (Day 4–5).

The amsmath Package

```
\usepackage{amsmath}
```

Why & What: This single line has no visible output on its own, but load it in **every** paper with math – it is the standard extension to LaTeX's native math tools. Without it, the multi-line derivations (`align`), the matrices, and several symbols used constantly in economics are simply unavailable. Every math example for the rest of today assumes `amsmath` is loaded.

Subscripts and Superscripts

```
$x_i$               % single-character subscript
$Y_{it}$            % braces needed for multi-character
$X_{i,t-1}^{2}$     % subscript AND superscript, lagged
```

Compiled Output

$$x_i \qquad Y_{it} \qquad X_{i,t-1}^{2}$$

Why & What: _ makes a subscript, ^ makes a superscript. **Critical rule:** without braces, only the *first character* is affected – `Y_it` silently renders as Y_it (wrong: only "i" is subscripted), not Y_{it} (correct). Always brace multi-character sub/superscripts – this is the exact notation you'll use for panel data: Y_{it}, $X_{i,t-1}$.

Greek Letters and Common Symbols

```
$\alpha$  $\beta$  $\theta$  $\lambda$  $\sigma$
$\Sigma$  $\Delta$  $\Omega$  $\infty$
```

Compiled Output

$$\alpha\ \beta\ \theta\ \lambda\ \sigma \qquad \Sigma\ \Delta\ \Omega\ \infty$$

Why & What: Every Greek letter used in economic notation has a matching command: lowercase names give lowercase letters (`\alpha` $\rightarrow \alpha$), capitalized command names give capital letters (`\Sigma` $\rightarrow \Sigma$). These only work **inside math mode** (between $ signs) – typing `alpha` outside math mode just prints the word "alpha". Full reference: Overleaf – "List of Greek letters and math symbols".

Operators: Sums, Products, Limits, Max

```
$\displaystyle\sum_{i=1}^{n} x_i \qquad \lim_{x\to\infty} \qquad
\operatorname*{argmax}_{x} f(x)$
```

Compiled Output

$$\displaystyle\sum_{i=1}^{n} x_i \qquad \lim_{x\to\infty} \qquad \operatorname*{argmax}_{x} f(x)$$

Why & What: `\sum`, `\prod`, and `\lim` take `_` and `^` to set their bounds, exactly like subscripts. `\displaystyle` forces the "full-size" rendering (bounds above/below the symbol) even inline. `\operatorname*{argmax}` is how you typeset operators LaTeX doesn't already know, like *argmax* or *argmin*, with a subscript stacked underneath.

Fractions and Binomials

```
$\varepsilon_d = \dfrac{\%\,\Delta Q_d}{\%\,\Delta P}
\qquad \dbinom{n}{k} = \dfrac{n!}{k!(n-k)!}$
```

Compiled Output

$$\varepsilon_d = \frac{\%\,\Delta Q_d}{\%\,\Delta P} \qquad \binom{n}{k} = \frac{n!}{k!(n-k)!}$$

Why & What: `\frac{a}{b}` typesets a fraction; `\dfrac` forces the larger "display style" size even inline, which is usually what you want for readability. `\binom{n}{k}` typesets a binomial coefficient the same way. Both take exactly two braced arguments – numerator/denominator, or top/bottom.

Multi-line Derivations with align

```
\begin{align}
  \hat{\beta} &= (X'X)^{-1}X'Y \\
  \text{Var}(\hat{\beta}) &= \sigma^2 (X'X)^{-1}
\end{align}
```

Compiled Output

$$\hat{\beta} = (X'X)^{-1}X'Y$$
$$\text{Var}(\hat{\beta}) = \sigma^2(X'X)^{-1}$$

Why & What: `&` marks the point where every line should line up vertically – usually right before the = sign, which is why both equations above have their equals signs stacked. `\\` ends each line. Plain `align` numbers every line (as it would here); `align*` suppresses numbering entirely.

Matrices: Linear Algebra & Game Theory

```
$\begin{pmatrix} 1 & 0.5 \\ 0.5 & 1 \end{pmatrix}
\qquad
\begin{pmatrix} (3,3) & (0,5) \\ (5,0) & (1,1) \end{pmatrix}$
```

Compiled Output

$$\begin{pmatrix} 1 & 0.5 \\ 0.5 & 1 \end{pmatrix} \qquad \begin{pmatrix} (3,3) & (0,5) \\ (5,0) & (1,1) \end{pmatrix}$$

Why & What: Inside `pmatrix`, rows are separated by `\\` and entries within a row by `&` – the same grid logic as a `tabular` table (Day 3). The left matrix is a correlation matrix; the right is a 2×2 game-theory payoff matrix. `pmatrix` gives parentheses, `bmatrix` gives square brackets, `vmatrix` gives determinant bars.

Labeling and Referencing Equations

```
\begin{equation}
  \label{eq:cobb-douglas}
  Y = A K^{\alpha} L^{1-\alpha}
\end{equation}

As shown in Equation~\eqref{eq:cobb-douglas}, output depends on...
```

Compiled Output

$$Y = AK^{\alpha}L^{1-\alpha} \tag{1}$$

As shown in Equation (1), output depends on...

Why & What: `\label{...}` silently tags the equation right after it is numbered – it produces **no visible output** by itself. `\eqref{...}` is what turns that tag into the visible **"(1)"** in your sentence – and it **stays correct automatically** even if you add or remove equations earlier in the paper. This is the exact mechanism you'll reuse for tables, figures, and sections all week.

Hands-on Exercise

Typeset the following three items from scratch in a new Overleaf document (remember `\usepackage{amsmath}`):

1. A **Cobb-Douglas production function**: $Y = AK^{\alpha}L^{1-\alpha}$, numbered and labeled.
2. A **linear regression equation** with a subscripted error term: $Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i$.
3. A **2×2 game-theory payoff matrix** using `pmatrix`.

Reference the Cobb-Douglas equation by number in a sentence below it using `\eqref`.

Homework Before Day 3

Homework

Add the full set of equations from your running paper draft (or, if it has none yet, from a model relevant to your field) into the document you started on Day 1. Label every numbered equation.

Resources for today:

- Overleaf – "Mathematical expressions" / "Subscripts and superscripts"
- Overleaf – "Fractions and Binomials" / "Aligning equations with amsmath"
- Overleaf – "List of Greek letters and math symbols" / "Matrices"
- Wikibooks LaTeX – Mathematics chapter

Coming Up: Day 3

Tables, Figures & Regression Output

Publication-quality tables with `booktabs`, figures, and a fast workflow from Excel/Stata output to LaTeX.

Thank You

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