## Chapter 2: Sequences through Excel

## PURPOSE OF THIS CHAPTER READING:

- To introduce you to what you will be seeing when you work with Excel
- To cover some basic ideas about sequences that you will explore in Excel
- To provide important information about how Excel draws charts


## QUICK START GUIDE:

Although we expect you to read this entire document before you begin work in Microsoft Excel, we offer FOUR important tips below for those of you who want to dive right in and start exploring the C2Lab.xls workbook. Different computer monitors and Excel display options make it impossible to standardize the display of our workbooks. Use the Text Box Format option and other hints below to customize our workbooks to your particular computer monitor. Don't hesitate to click and move objects as needed!


If a button is in the wav, hold down the CONTROL (CTRL) key, then click on the button to select it. With the cursor as an arrow, click on one of the sides and drag it away.

## IMPORTANT INFORMATION ABOUT EXCEL MACROS

Whenever you open one of the workbooks in the Economic Approach with Microsoft Excel or any workbook with embedded macros, Excel will prompt you with a dialog box like this one:

## Microsoft Excel x

The workbook you are opening contains macros.
Some macros may contain viruses that could be harmful to your computer.

If you are sure this workbook is from a trusted source, click 'Enable Macros'. If you are not sure and want to prevent any macros from running, click 'Disable Macros'.

Tell Me More

## Always ask before opening workbooks with macros



You can be sure that the workbooks associated with the Economic Approach with Microsoft Excel can be trusted. Thus, you should click on the Enable Macros button. By doing so, you will access a variety of tools and hints built into our workbooks.

You should understand, however, that not all workbooks are to be trusted. While the Visual Basic language that supports Excel provides legitimate authors and developers with a flexible, powerful tool, that same power can be used against you. An evil Excel (or Office) macro could delete the contents of your hard drive and do other terrible things. You should be very careful when opening an Excel (or Office) file that has embedded macros. If you are at all unsure, click on the Disable Macros button.

Be particularly wary of attachments sent via e-mail. Viruses, worms, and other nasty virtual organisms can cause a lot of trouble.

Note that the default button is the Disable Macro button. If you simply hit Return, you are disabling macros. The Excel workbook (or Word document or PowerPoint presentation) will open, but none of the macros will run or work.

In summary, to use our Excel workbooks you should click on the Enable Macros button. If you are ever unsure of a file's source, do NOT open the file.

## WHAT'S ON THE SCREEN WHEN YOU START EXCEL:

When you first launch Excel, you will be looking at a blank worksheet. Within the sheet are cells. The active cell is the cell which is currently highlighted by being outlined in bold. The address of each cell is its location in the sheet: e.g., the address of the active cell might be A1 (column A, row 1). The worksheet is part of a workbook which contains several worksheets. The worksheets are separated by sheet tabs (on the bottom left-hand side of the screen) which you can use to go from one sheet to the next within the workbook.

Think of the workbook as being a notebook that is separated into sections by colored dividers. Each section is a worksheet and the whole thing together is a workbook.

Other important things to be familiar with before you begin actually working with Excel include:

## - Mouse pointer:

This tells you the location of the mouse on the screen. When you first launch Excel and are staring at a blank worksheet, it is probably shaped like a fat plus sign, $\}$. This is the shape when the cursor is over a cell. However, it changes shape depending upon what kind of object it is pointing to and what the computer is doing. This is VERY IMPORTANT.

When the computer is taking time to do something (like a calculation or sorting), it will be shaped like a clock (on a Mac ) or an hourglass (in Windows). This means you should give the computer a few seconds to think before you proceed.
Moving the mouse around on the mouse pad moves the pointer. If you point to different areas of the screen, the pointer changes. You should notice under what circumstances the pointer turns into an arrow, an I-bar, $\overline{\text { an }}$, or a thinner plus sign, $\boldsymbol{+}$

## LESSON: The kind of pointer you see on the screen provides valuable information about what you can do.

## - Scroll bars:

These are located along the right edge of the screen and along the bottom right-hand side of the screen. Located within the scroll bars are square boxes, called scroll boxes. By clicking and dragging the scroll box, you can move though the worksheet any distance. If you want to move quickly or have a long way to move, you can move one screen at a time by clicking in the gray area of the scroll bar (e.g., move down one screen by clicking in the area beneath the scroll box in the right-hand scroll bar). If you have only a short distance to go, you can move one row (or column) at a time by clicking on the arrows at the ends of the scroll boxes.


TIP: Although you can move around the worksheet using the scroll bars, in this course, you can navigate through the workbooks by clicking on the handy buttons (which are descriptively labeled, e.g., "Next Screen").

If a button is the way, hold down the CONTROL (CTRL) key and click on the button so that the button's border is highlighted. Then with the cursor as an arrow, click on one of the sides of the button and drag it out of the way.

## - Menu bar:

A row of words located across the top of the window. This is the basic mouse method to tell Excel what you want to do with the worksheet.
会 Eile Edit Diew Insert Format Tools Data Window

- Tool bar: A row of "buttons" located under the Menu bar. These are handy tools you can select to perform various operations. You will learn how to use a few of these tools or buttons in C2Lab.xls.

- Name Box and Formula Bar:

Your current active cell (see below) position in the spreadsheet is registered in the name box on the left part of the formula bar (just beneath the tool bars).


TIP: The Name Box will always report where the "active cell" is.

## - Cells:

The spreadsheet itself is a grid of rows (denoted by numbers) and columns (denoted by letters). Each cell is the intersection of a row and column. Cell D25 is where column D and row 25 intersect.

The cell in the top left-hand corner is A1, while the bottom right-hand corner cell is IV16384. There are 256 columns in an Excel worksheet (column 27 is AA , column 28 is AB , column 52 is AZ , column 53 is BA , and column 256 is IV) and, more obviously, 16,384 rows. Excel 97 has twice as many rows!

The active cell is that cell that has been selected (by clicking on it with the mouse or moving to it with the arrows, tab, or return keys on the keyboard). Usually, you select the cell you want and then enter in data or choose a command. Only one cell can be active at a time-you know which cell is the active cell because it has a heavy border around it.

## TIP: Things are selected in Excel when they have heavy or otherwise highlighted borders.

## - Cell References:

You can think of a spreadsheet as a map with avenues (columns) and streets (rows):

|  | A | B | C |
| :---: | :---: | :---: | :---: |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |

You can indicate cells by a column:row definition. So, for example B3 means the cell in column B and row 3.

We can continue our map analogy by noting that there are TWO WAYS TO GIVE DIRECTIONS:

- Relative directions
- Absolute directions

Relative directions depend on where you are initially, while absolute directions do not.

## Relative Directions:

Say your out-of-town friend couldn't find your house so she calls you from the corner of Main and $10^{\text {th }} \mathrm{St}$. "Just go two blocks north and take a right at the light. I'm the second house on the left," you say. That's a relative direction because it depends on the fact that she's starting out on the corner of Main and $10^{\text {th }} \mathrm{St}$. If she'd called you from anywhere else, those directions would NOT work. Relative directions depend on where you start.

## Absolute Directions:

If you had sent your friend a street map, she could see that your house is on a particular, absolute point on the map. From anywhere, she could get to your house by keeping an eye on the absolute place (your house) that she wants to be.

A spreadsheet is just like a map. If you want to use a particular cell, you can do so in either of TWO WAYS:

Relative reference OR Absolute reference
Relative references refer to another cell based on its relative position to the cell that contains the formula, while absolute references refer to cells based on their absolute position in the spreadsheet.

## Relative References:

Cell B3 contains a relative reference to cell A2. It tells Excel to use the value of cell A2 in cell B3, so that Excel reports the value of "2" in cell B3:

|  | A | B | C |  | A | B | C |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 |  |  |  | 1 |  |  |  |
| 2 | 2 |  |  | 2 | 2 |  |  |
| 3 |  | = A2 |  | 3 |  | 2 |  |
| 4 |  |  |  | 4 |  |  |  |
| 5 |  |  |  | 5 |  |  |  |

If you copy with cell B3, Excel will change the reference to always indicate "one cell to the left and one cell up." If you copied cell B3 into B4, Excel would report " 0 " in B4 because there's nothing in cell A3 and that's what is one cell left and one cell up from B3!

## Absolute References:

Cell B3 contains an absolute reference to cell A2. The " $\$$ " tells Excel to use the value of cell A2 in cell B3, so that Excel reports the value of " 7 " in cell B3:

|  | A | B | C | A | B | C |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 |  |  |  |  |  |  |
| 2 | 2 |  |  | 2 |  |  |
| 3 |  | $=\$ A \$ 2+5$ |  |  | 7 |  |
| 4 |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |

If you copy with cell B3, Excel will NOT change the reference-it will always use cell A2. If you copied cell B3 into B4, Excel would report " 7 " in B4 because it would use the " 2 " from cell A2 plus the 5 in its calculation.

## The Important Lesson Here:

Relative and absolute references are two ways to refer to a cell. They are crucial to understanding how a spreadsheet works. Depending on what you want to do, it may be better to use a relative or an absolute reference. As you get better and better at using spreadsheets, you will learn when it is appropriate to use a relative or an absolute reference.

You will put this important lesson to practical use in C2Lab.xls.

Although we could go on and on describing Microsoft Excel, we believe the above provides you with the necessary basics to begin working with Excel-which is, after all, the only way to really understand how to use Excel.

Before you begin your first Excel experience, however, we offer some additional material on sequences-the topic covered in C2Lab.xls.

## BACKGROUND INFORMATION ON SEQUENCES:

Arithmetic and Geometric Sequences (or progressions) are two common kinds of "chains of numbers."

An Arithmetic Sequence is one in which the numbers change by a constant difference.

For example, 1, 4, 7, 10, 13, 16, 19 is a finite, arithmetic sequence. The constant difference is 3 .

An example of an infinite arithmetic progression is $10,20,30,40, \ldots$ Of course, the constant difference is 10 and the 3 little dots (". . ." which are called an "ellipsis") means that, unlike the finite sequence, "it keeps going and going forever."

A Geometric Sequence is one in which the numbers change by a constant ratio.

For example, 1, 2, 4, 8, 16 is a finite, geometric sequence. The constant ratio is 2: if you divide a number in the series by its predecessor, you will always get $2.2 / 1$ is 2 , $4 / 2$ is 2 , etc. Sometimes, the constant ratio is expressed as in percentage terms. In this case, the constant ratio expressed as a percentage growth rate is $100 \%$.

Note the following pattern:
Arithmetic Sequence : Constant Difference : : Geometric Sequence : Constant Ratio Arithmetic Sequence : Addition :: Geometric Sequence : Multiplication

## ASIDE on Percentages:

Percent means, literally, per hundred. Percent is just a transformation of a number to "per hundred" terms. The number 6 , if interpreted as 6 per 1 , is the same as $600 \%$ because that's 600 per 100 . If someone makes 3 out of 4 , that's $3 / 4,0.75,75 \%$, or 60 per 80 (a ridiculous transformation that no one would really use because we're not used to thinking "per 80 "). The four ways of communicating " 3 out of 4 " (fraction, decimal, percent, and "per 80") are equivalent. We use per hundred so often that we invented the percentage sign, $\%$, so we wouldn't have to write "per hundred" all the time.

Now, in the Geometric Series above, going from 1 to 2 is a $100 \%$ increase because there's an increase of 1 (from 1 to 2 ) per 1 or 100 per 100 or $100 \%$. From 2 to 4, we have an increase of 2 per 2 or 100 per 100 or $100 \%$.

Of course, there are other ways to find the percentage increase, including:

$$
\left(\frac{\text { new value }- \text { initial value }}{\text { initial value }}\right) \times 100=\left(\frac{\text { new value }}{\text { initial value }}-1\right) \times 100
$$

Try it out for yourself on 1 to 2 and 2 to 4 . You get $100 \%$ either way you do it.

But what's important is to remember that percent means per hundred. It's neither mysterious nor particularly difficult.

## BACK to Geometric Progressions:

An example of an infinite, geometric progression is $10,100,1000,10000, \ldots$ Of course, the constant ratio is 10 . The constant ratio expressed as a percentage growth rate is $900 \%$. (Sure, from 10 to 100 is an increase of 90 per 10 or 900 per 100 or $900 \%$. From 100 to 1000, we could calculate, $[(1000-100) / 100] \times 100=900 \%$. Finally, from 1000 to 10000 , we could calculate, $[(10000 / 1000)-1] \times 100=900 \%$. You always get the same answer.)

Another example is $1,1.1,1.21,1.331, \ldots . H m m m$, what's the constant ratio here? What is the constant ratio expressed as a constant percentage growth rate?

You should be able to figure out the answer to the question and write your answer in the space provided above. Turn the page to see the answer.

The answers:
1.1.
$10 \%$

Some students might say, "This is, like, really boring. Why are you telling me this?"

Well, our answer is that many interesting real world phenomena can be described by GEOMETRIC SEQUENCING. For example, the spread of certain infectious diseases, how much money you accumulate in the bank, and the process of cell division exhibit geometric sequencing. As you will soon see, this has interesting implications.

Also, exploring sequences will help us show off the power of Excel. When it comes to making cumbersome calculations, nobody beats a computer. You will see what we mean when you open C2Lab.xls.

Having learned about Arithmetic and Geometric Sequences (not to mention a brief review of percentages), we can move on to an important result:

It turns out that

## Geometric Sequences ALWAYS catch up and beat Arithmetic Sequences.

The "ALWAYS" is pretty important. "Always" is a strong word. It doesn't mean "sometimes," or "usually." There are no special starting places for the two series. No matter how far apart they are at the start, how large the constant difference is, or how small the constant ratio is (so long as it is greater than one), the geometric sequence will catch up and beat the arithmetic sequence. That's pretty amazing.

One intuitive explanation for this is that Geometric Sequences are more "powerful" because they involve multiplication while Arithmetic Sequences use addition.

To show what the important result means, suppose we start two series out at 1 , then add 20 to the first series and multiply by 2 for the second series. The first series is ahead for a little bit-because 21 is bigger than 2 and 41 is bigger than 4 .

But then the Geometric Series starts really gaining steam and it eventually passes the Arithmetic Series. If we think of the initial value of 1 at a time period, say $t=0$, then we could show that the Geometric Series passes the Arithmetic Series in time period $\mathrm{t}=8$ :


The table and graph show pretty clearly that, although the Arithmetic Series has an early lead and the Geometric Series grows slowly at first, when the Geometric Series gets rolling-look out!

The fact that a geometric series may start chugging slowly at first but will eventually grow extremely rapidly is, of course, the principle behind saving for retirement. You can't really start saving for retirement when you're 50 because that doesn't give you much time to really get rolling. If you save even a small amount when you are young, you give your savings the time it needs to grow to substantial sums.

But the example above doesn't really drive the point home. We're saying that, no matter where you start from (that's not infinity-you have to start from some specific number) and no matter what the constant difference and constant ratios are (as long as the constant ratio is greater than one),

Geometric Sequences always catch up and beat Arithmetic Sequences.

So, say you start an Arithmetic Sequence at $\$ 1,000,000$ and add $\$ 1,000,000$ every day and you compare that to a Geometric Sequence that starts at \$1 and grows at 10\% per day. We're saying that, eventually, the Geometric Sequence will pass the Arithmetic Sequence. Really. It will. On which day? YOU will figure that one out in the lab.

Now that you've learned about Geometric and Arithmetic Sequences (and percents) and the important (and maybe even hard to believe) result that Geometric Sequences always catch up and beat Arithmetic Sequences, we have only to discuss the Rule of 70 before YOU can begin work on C2Lab.xls.

The Rule of 70 is an approximation, a "rule of thumb," that you can use to quickly determine how long it will take a Geometric Series to double.

> The Rule of 70: A Geometric Sequence growing at $x \%$ per year will double in
> approximately $70 / \mathrm{x}$ years.

So, for example, a sequence cranking away at a constant ratio of 1.1 (or $10 \%$ per year), will double in about 7 years. If it grows at $20 \%$, it'll take about $31 / 2$ years; while a constant ratio of $1 \%$ will take about 70 years.

This rule is useful because you can quickly gauge the effect of a Geometric Sequence's constant ratio in terms of doubling. Say you heard that the price level, as measured by the Consumer Price Index, went up 7\% last year. You could quickly conclude that if the inflation rate stayed constant at $7 \%$, the price level would double in roughly 10 years.

Armed with some basic ideas about Excel and sequences, you are ready to embark on your first Excel chapter, C2Lab.xls. Go slowly and carefully and remember, YOU are in control. When you need to draw a graph, read the next section to learn how.

## Creating a Chart in Microsoft Excel

We want to graph the geometric and arithmetic sequences in order to learn about the graphics capabilities of Excel. Excel has a nice feature called "Chart Wizard" which prompts you at each step of the process.

We'll show you how to make a simple chart, but you should experiment with the many chart types and design options available in Excel.

Read the instructions below carefully and do each step in order:

1. Select the cells you want to graph including the text that describes the data

- Always select from the top left to the bottom right. Selecting right to left or down to up seems to sometimes confuse Excel.
- You can select non-contiguous (or non-adjacent) cells by holding down the COMMAND key on a Mac or the CRTL key in Windows after you select the first cell or group of cells. Hold down the CTRL or COMMAND key every time you want to add non-contiguous data to already selected data.

TIP: Holding down the CTRL or COMMAND key before you start selecting the data you want to graph is a common error and will seriously confuse Excel. Select the first range of cells, THEN hold down the CTRL or COMMAND key and select the next range.
2. Click on the Chart Wizard button in the toolbar,


NOTE: If you place the cursor over a toolbar button and wait a second or two, Excel shows you the name of the button. In the picture above, Excel indicates that the cursor is resting over the Chart Wizard button.
3. After you click on the Chart Wizard button, Excel brings up the first of four steps that are involved in making a chart. Choose XY Scatter as the type of chart and "Scatter with data points connected by lines" as the chart sub-type. Click the Next button when you are ready.


NOTE: XY Scatter is the most common type of chart used in economics because we are often interested in showing how one variable depends on another.
4. In Step 2, you choose the Chart Source Data. Excel guesses (based on the select you selected) if the data are organized in rows or columns. You can see the effect of changing this option by clicking on the radio button.


Use the Data range line to verify your selected source data. If it is wrong, you can edit the reported range or delete the entire range and use the mouse to select a new range. If the dialog box is in the way, click on the Collapse Dialog button 켴 to temporarily remove the dialog box. Click on it again to bring the dialog box back.
5. At Step 3 of 4, you have a variety of design options:


In the Titles group, you can edit (or add) the chart title and add X and Y axis labels.

Click on the other tabs to see what options are available. With a bivariate scatter like the one above, you should click on the Legend tab and click off the Show Legend option.
6. At Step 4 of 4, choose where to place the chart. Usually, you'll place it directly on the worksheet.


Click the Finish button to have Excel place the completed chart on the worksheet.

Once the chart is on the sheet, you can edit and make a variety of changes. Before explaining how to do this, let's take a moment to review two common charting errors.

## Two Common Graphing Mistakes to Avoid:

## 1) The "Series 1 " legend text

If the group of cells that you select to build the chart do NOT contain cells with text in the first row and you ask for a legend, Excel complies by creating a legend box with the "Series \#" as the legend:

| Quantity | Profit |  |  |  |
| ---: | ---: | ---: | :---: | :---: |
| 0 | $\$$ | - |  |  |
| 10 | $\$$ | 300 |  |  |
| 20 | $\$$ | 400 |  |  |
| 30 | $\$$ | 300 |  |  |$\quad$| Only the cells with numbers |
| :--- |$\quad$| are selected before the Chart |
| :--- |
| Wizard tool is clicked, yet a |
| legend is asked for. |



This is NOT good graphing. "Series 1" means nothing.

Solution?
A) If you want a legend, make sure that the first row (if your data are organized in rows) of your selected data range has text for the legend.
B) Do not ask for a legend (click off the Show Legend option in the Legend tab of Step 3, Chart Options) or, after the dreaded "Series 1" legend is displayed on your graphic, click on the legend to highlight it, and hit the "Del" or "Delete" key (NOT the backspace key) to remove the legend.

TIP: If you are graphing only one variable against another, a legend is unnecessary. Legends should be used only when graphing many variables.

NOTE: The name that appears in the legend box is contained in the Series tab of Step 2, Chart Source Data.

## 2) The Poorly Chosen Axis Range

While Excel can usually be counted on to make good choices concerning the x and y axes range, it is up to you to make sure that the range on each axis is appropriate.


In the graph above, the y axis ranges from 0 to $\$ 4,000$, but the data points go from only 0 to $\$ 400$. The y axis range is chosen poorly here.

Solution?

Double-click on the y axis. This will bring up the Format Axis dialog box. Click on the Scale tab and then change the range of the axis by altering the values to better display the data.

TIP: When you want to change something in Excel, DOUBLECLICK on it!

## Editing a Chart in Excel

## Sizing

If you want to change the size of the picture, you can click on one of the 'handles' located on the corners and sides of the box and drag it until you have obtained the desired dimensions. These handles show up only when the 'object' (in this case, the chart) has been selected.

You can also move the whole picture by clicking and dragging it if the cursor is in the shape of an arrow.

## Editing

Making changes to an already created chart in Excel is pretty easy. The general rule, as mentioned in the tip above, is to double-click on whatever you are interested in changing. Excel will prompt you with a dialog box that contains the available options. Try it yourself. Double-click on the x and y axes, the series, the plot area and the chart area.

If you let the cursor rest for a moment, Excel tells you what object you have under the cursor. This helps if you are having trouble getting the options for a particular part of the chart.

You can also make changes via the menu bar. Select the part of the chart you want to change and then click on the Format menu item.

Notice that when you click on a chart, the menu bar changes and a Chart menu item appears. You can change the Chart Type and choose a variety of other options as shown in the picture below:

| Chart | Window |
| :--- | :--- |
| Help |  |
| Chart Iype... |  |
| Source Data... |  |
| Chart options... |  |
| Location... |  |
| Add Data... |  |
| Add Trendline... |  |
| 3-D Wew... |  |

## Quick Chart Editing

A powerful way to make changes is by directly editing the series. Click on the series and note that the source data appears as a formula in the formula bar. The first part is the legend text, then comes the x axis, then the y axis (each separated by a comma).

The charts below show how the series formula determines the chart being depicted. Note how the axes are switched by changing the order in which the data ranges $\$ \mathrm{~A} \$ 2: \$ \mathrm{~A} \$ 5$ and $\$ \mathrm{~B} \$ 2: \$ \mathrm{~B} \$ 5$ appear in the series formula.

|  | A | B | C | D |  | E | F | G |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Quantity | Profit | 40 Quantity |  |  |  |  |  |
| 2 | 0 | \$ |  |  |  |  |  |  |
| 3 | 10 | \$ 300 | 3020 |  |  |  |  |  |
| 4 | 20 | \$ 400 |  |  |  |  |  |  |
| 5 | 30 | \$ 300 | $\begin{array}{r} 10 \\ 0 \end{array}$ |  |  |  |  |  |
| 6 |  |  |  | 1 |  | , |  |  |
| 7 |  |  | \$- | \$100 | \$200 | \$300 | \$400 |  |
| 8 |  |  |  |  |  |  |  |  |
| 9 |  |  |  |  |  |  |  |  |
| 10 |  |  | $\$ 500 \sim$ Profit |  |  |  |  |  |
| 11 |  |  |  |  |  |  |  |  |
| 12 |  |  | ${ }_{\$ 300} 9400$ | - | - | - |  |  |
| 13 |  |  | ${ }_{\$ 1000}$ |  |  |  |  |  |
| 14 |  |  |  |  |  |  |  |  |
| 15 |  |  |  |  |  |  |  |  |
| 16 |  |  |  |  |  | 20 | 30 |  |
| 17 |  |  |  |  |  |  |  |  |
| 18 |  |  |  |  |  |  |  |  |

You can copy and paste a chart, then change the series by simply editing the series in the formula bar.

## Summary

Now that you know how to make and edit a graph in Excel, you are ready to graph the arithmetic and geometric sequences. Remember to properly label the axes, title the graph and make a good visual representation of what you are graphing. Good luck!

