Using Excel

For *Principles of Econometrics, Fourth Edition*

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Genevieve Briand dedicates this work to Tom Trulove

Carter Hill dedicates this work to Todd and Peter

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Preface

This book is a supplement to *Principles of Econometrics, 4th Edition* by R. Carter Hill, William E. Griffiths and Guay C. Lim (Wiley, 2011). This book is not a substitute for the textbook, nor is it a stand alone computer manual. It is a companion to the textbook, showing how to perform the examples in the textbook using Excel 2007. This book will be useful to students taking econometrics, as well as their instructors, and others who wish to use Excel for econometric analysis.

In addition to this computer manual for Excel, there are similar manuals and support for the software packages EViews, Gretl, Shazam, and Stata. In addition, all the data for *Principles of Econometrics, 4th* in various formats, including Excel, are available at **http://www.wiley.com/college/hill**. Individual data files, as well as errata for this manual and the textbook, can also be found at **http://principlesofeconometrics.com**.

The chapters in this book parallel the chapters in *Principles of Econometrics, 4th*. Thus, if you seek help for the examples in Chapter 11 of the textbook, check Chapter 11 in this book. However within a Chapter the sections numbers in *Principles of Econometrics, 4th* do not necessarily correspond to the Excel manual sections.

This work is a revision of *Using Excel 2007 for Principles of Econometrics, 3rd Edition* by Genevieve Briand and R. Carter Hill (Wiley, 2010). Genevieve Briand is the corresponding author.

We welcome comments on this book, and suggestions for improvement. [*]

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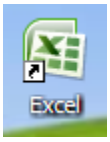
CHAPTER 1

Introduction to Excel

CHAPTER OUTLINE

1.1 STARTING EXCEL

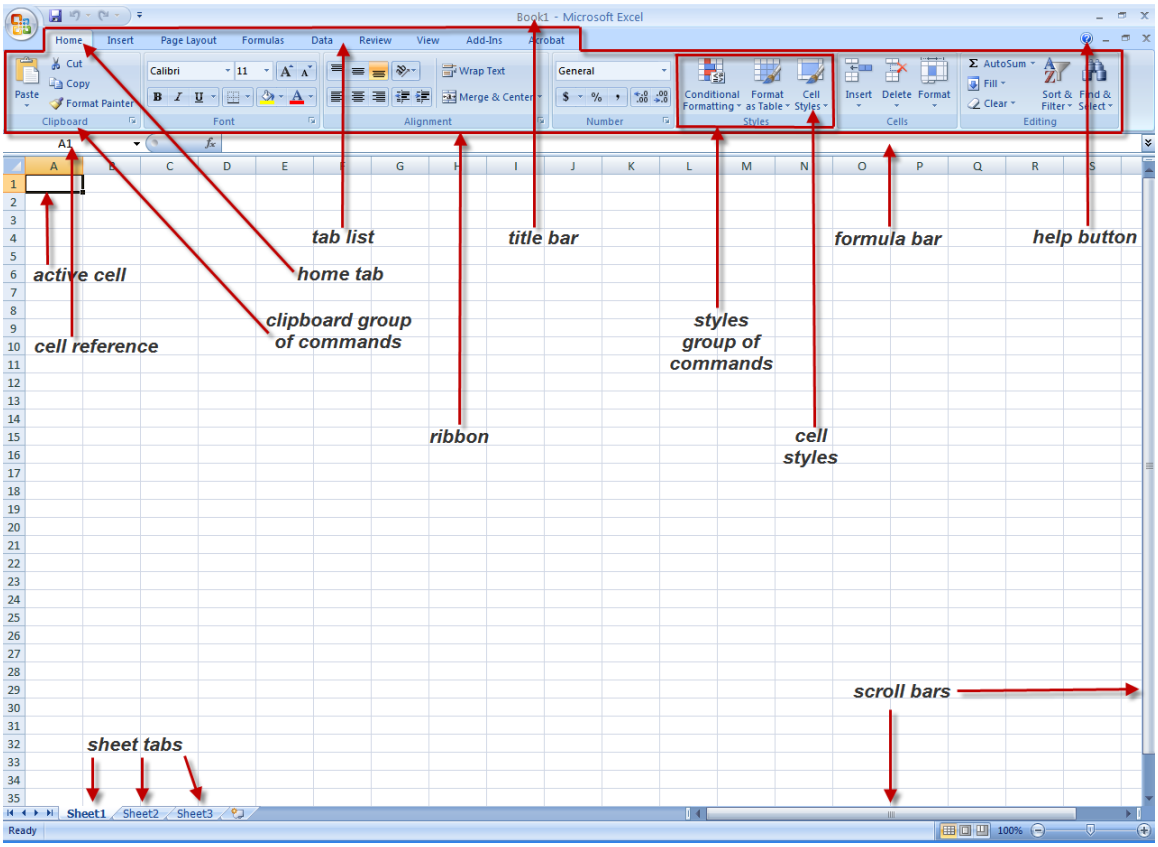
Find the **Excel** shortcut on your desktop. Double click on it to start Excel (left clicks).



Alternatively, left-click the **Start** menu at the bottom left corner of your computer screen.

Slide your mouse over **All programs**, **Microsoft Office**, and finally **Microsoft Office Excel 2007**. Left-click on this last one to start Excel—or better yet, if you would like to create a shortcut, right-click on it; slide your mouse over **Send to**, and then select (i.e. drag your mouse over and left-click on) **Desktop (create shortcut)**. An Excel 2007 short-cut is created on your desktop. If you right-click on your shortcut and select **Rename,** you can also type in a shorter name like Excel.

Excel opens to a new file, titled Book1. You can find the name of the open file on the very top of the Excel window, on the **Title bar**. An Excel file like Book1 contains several sheets. By default, Excel opens to Sheet1 of Book1. You can figure out which sheet is open by looking at the **Sheet tabs** found in the lower left corner of your Excel window.



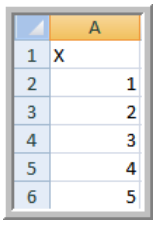
There are lots of little bits that you will become more familiar with as we go along. **The Active cell** is surrounded by a border and is in Column A and Row 1; its **Cell reference** is **A1**.

Below the title bar is a **Tab list**. The **Home tab** is the one Excel opens to. Under each tab you will find groups of commands. Under the home tab, the first one is the **Clipboard group of commands**, named after the tasks it relates to. The wide bar including the tab list *and* the groups of commands is referred to as the **Ribbon**. The content of the **Active cell** shows up in the **Formula bar** (right now, there is nothing in it). Perhaps the most important of all of this is to locate the **Help button** on the upper right corner of the Excel window. Finally, you can use the **Scroll bars** and the arrows around them to navigate up-down and right-left in your worksheet. And you have a long way to go: each worksheet in Microsoft Excel 2007 contains 1,048,576 rows and 16,384 columns!!!!

Note that your **Ribbon** might look slightly different than the one shown above. If your screen is bigger, Excel will automatically display more of its available options. For example, in the **Styles** group of command, instead of the **Cell styles** button, you might have a colorful display of cell styles.

1.2 ENTERING DATA

We will use Excel to analyze data. To enter labels and data into an Excel worksheet move the cursor to a cell and type. First type **X** in cell **A1**. Press the **Enter** key on your keyboard to get to cell **A2** or navigate by moving the cursor with the mouse, or use the **Arrow** keys (to move right, left, up or down). Fill in the rest as shown below:



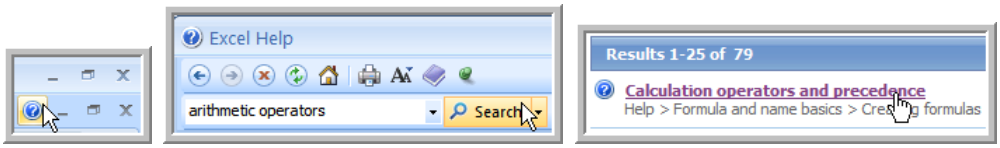
	A
1	X
2	1
3	2
4	3
5	4
6	5

1.3 USING EXCEL FOR CALCULATIONS

What is Excel good for? Its primary usefulness is to carry out repeated calculations. We can add, subtract, multiply and divide; and we can apply mathematical and statistical functions to the data in our worksheet. To illustrate, we are going to compute the squares of the numbers we just entered and then add them up. There are two main ways to perform calculations in Excel. One is to write formulas using arithmetic operators; the other is to write formulas using mathematical functions.

1.3.1 Arithmetic Operations

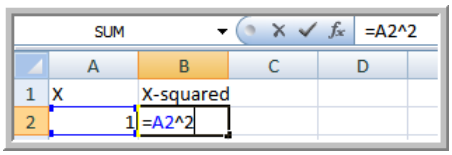
Select the **Excel Help** button in the upper right corner of your screen. In the window of the **Excel Help** dialog box that pops up, type **arithmetic operators** and select **Search**. In the list of results, select **Calculation operators and precedence**.



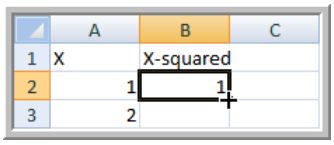
Standard arithmetic operators are defined as shown below. To close the Excel help dialog box, select the **X** button found on its upper right corner.

Arithmetic operator	Meaning	Example
+ (plus sign)	Addition	3+3
– (minus sign)	Subtraction Negation	3–1 –1
* (asterisk)	Multiplication	3*3
/ (forward slash)	Division	3/3
% (percent sign)	Percent	20%
^ (caret)	Exponentiation	3^2

Place your cursor in cell **B1**, and type **X-squared**. In cells **B2** through **B6** below (henceforth referred to as **B2:B6**), we are going to compute the squares of the corresponding values from cells **A2:A6**. *Let us emphasize that the trick to using Excel efficiently is NOT to re-type values already stored in the worksheet, but instead to use references of cells where the values are stored*. So, to compute the square of 1, which is the value stored in cell **A1**, instead of using the formula **=1*1**, you should use the formula **=A2*A2** or **=A2^2**. Place your cursor in cell **B2** and type the formula.

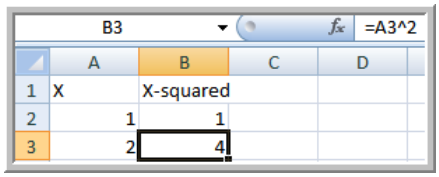


Then press **Enter**. Note that: (1) a formula always starts with an equal sign; this is how Excel recognizes *it is* a formula, and (2) formulas are not case sensitive, so you could also have typed **=a2^2** instead. Now, we want to copy this formula to cells **B3:B6**. To do that, place your cursor back into cell **B2**, and move it to the south-east corner of the cell, until the fat cross turns into a skinny one, as shown below:



Left-click, hold it, drag it down to the next four cells below, and release!

Excel has copied the formula you typed in cell **B2** into the cells below. The way Excel understands the instructions you gave in cell **B2** is "square the value found at the address **A2**". Now, it is important to understand how Excel interprets "address **A2**". To Excel "address **A2**" means "from where you are at, go left by one cell"—because this is where **A2** is located vis-à-vis **B2**. In other words, an address gives directions: left-right, up-down, and distances: number of cells away—all in reference to the cell where the formula is entered. So, when we copied the formula we entered in cell **B2**, which instructed Excel to collect the value stored one-cell away from its left, and then square it—those exact same instructions were given in cells **B3:B6**. If you place your cursor back into **B3**, and look at the **Formula bar**, you can see that, in this cell, these same instructions translate into "**=A3^2**".

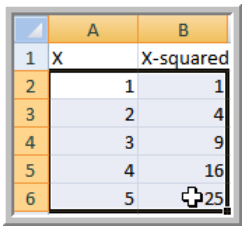


1.3.2 Mathematical Functions

There are a large number of mathematical functions. Again, the list of functions available in Excel can be found by calling upon our good friend **Help** button and type **Mathematical functions**. If you try it, you will be able to see that the list is long. We will not copy it here.

We did compute the squares of the numbers we had. Now we will add them up—the numbers, and the squares of the numbers, separately. For that, we will be using the **SUM** function.

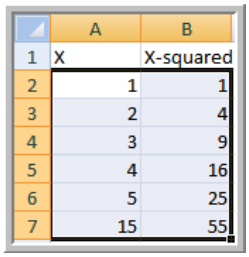
We first need to select or highlight all the numbers from our table. There are several ways to highlight cells. For this small area the easiest way is to place your cursor in **A2**, hold down the left mouse button and drag it across the area you wish to highlight—i.e. all the way to cell **B6**. Here is how your worksheet should look like:



	A	B
1	X	X-squared
2	1	1
3	2	4
4	3	9
5	4	16
6	5	25

Next, go to the **Editing** group of command, which is found in the extreme right of the **Home** tab, and select **Σ AutoSum**.

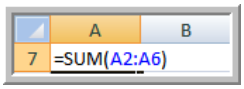
Excel sums the numbers from each column and places the sum in the bottom cell of each column. The result is:



	A	B
1	X	X-squared
2	1	1
3	2	4
4	3	9
5	4	16
6	5	25
7	15	55

Notice that if you select the arrow found to the right of **Σ AutoSum** you can find a list of additional calculations that Excel can automatically perform for you.

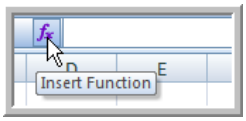
Alternatively, you could have placed your cursor in cell **A7**, typed **=SUM(A2:A6)**, and pressed the **Enter** key (and then copied this formula to cell **B7**).



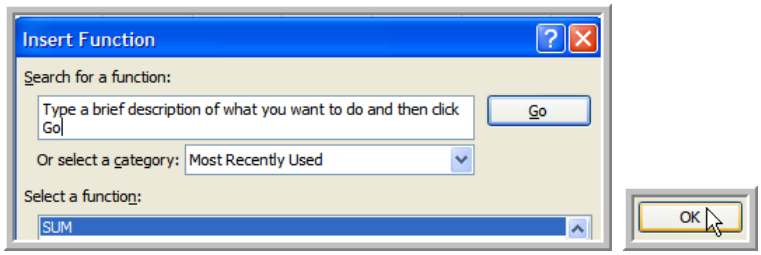
	A	B
7	=SUM(A2:A6)	

Note that: (1) as soon as you type the first letter of your function, a list of all the other available functions that start with the same letter pops up. This can be very useful: if you left click on any of them, Excel gives you its definition; if you double left-click on any of them, it automatically finishes typing the function name for you, and (2) once the function name and the opening parenthesis are typed, Excel reminds you of what the needed **Arguments** are, i.e. what else you need to specify in your function to use it properly.

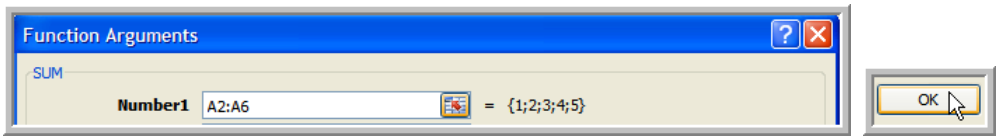
Now, you could also have used the **Insert function** button, which you can find on the left side of the **Formula bar**.



Once your cursor is placed in **A7**, select the **Insert function** button. An **Insert function** dialog box pops up. You can **Select a function** you need (highlight it, and select **OK**), or **Search for a function** first (follow the instructions given in that window).



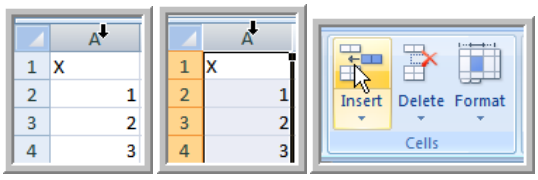
In the **Function Arguments** dialog box that pops up, you need to specify the cell references of the values you want to add. If they are not already properly specified, you can type **A2:A6** in the **Number 1** window, or place your cursor in the window, delete whatever is in it, and then select **A2:A6**. Select **OK**. Now that you have the formula in **A7**, copy it into **B7**.



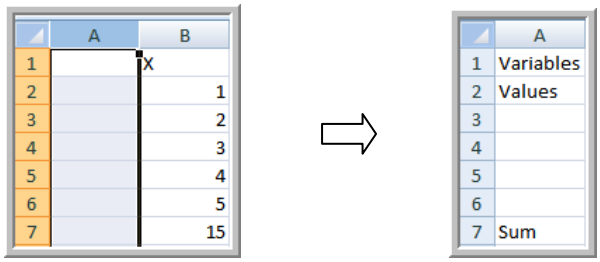
1.4 EDITING YOUR DATA

Before wrapping-up, you want to polish the presentation of your data. It actually has less to do with appearance than with organization and communication. You want to make sure that anyone can easily make sense of your table (like your instructor for example, or yourself for that matter—when you come back to it after you let it sit for a while).

We are going to add labels and color/shade to our table. Hold your cursor over cell **A** until it turns into an arrow-down; left-click to select the whole column; and select **Insert** in the **Cells** group of commands, found left to the **Editing** group of commands.

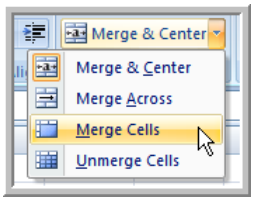


Excel adds a new column to the left of the one you selected. That's where we are going to write our labels. In the new **A1** cell, type **Variables**; in cell **A2**, type **Values**; in cell **A7** type **Sum**.

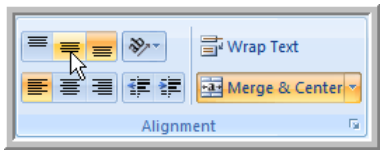


Select column **A** again, make it **Bold (Font** group of commands, right to the **Clipboard** one), and align it **Left (Alignment** group of commands, right to the **Font** one).

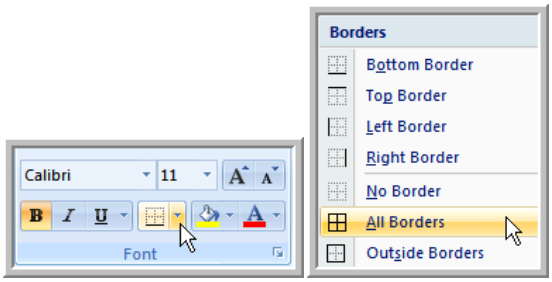
Select cells **B1** and **C1**, and make them **Bold**. Repeat with cells **B7** and **C7**. Better, but not there yet. Select row **7**, make it **Italic** (next to **Bold**). Select column **B**, hold your left-click and drag your mouse over cell **C** to select column **C** too; select **Center** alignment (next to **Left**). Next, select **A2:A6**; left-click the arrow next to **Merge & Center** (on the **Alignment** group of commands), and select **Merge cells**.



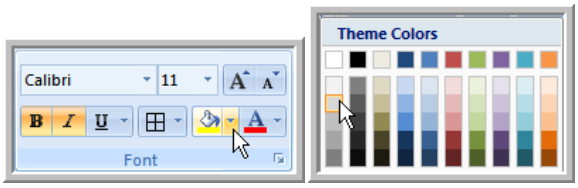
Immediately after**,** select **Middle Align**, which is found right above the **Center** alignment button.



Select **A1:C7**, left-click the arrow next to the **Bottom Border** button and select **All Borders**.



Select **A7:C7** (**A7:C7**, not **A1:C7** this time), left-click the arrow next to the **Fill Color** button, and select a grey color to fill in the cell with. Choose a different color for **A1:C1**.

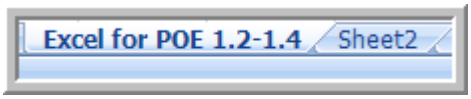


Finally, put your cursor between cells **C** and **D** until it turns to a left and right arrow as shown here:

Hold it there and double left-click so that the width of column **C** gets resized to better accommodate the length of the label "X-squared". The result is:

	A	B	C
1	**Variables**	**X**	**X-squared**
2		1	1
3		2	4
4	**Values**	3	9
5		4	16
6		5	25
7	***Sum***	***15***	***55***

Next, drag your cursor over the **Sheet1** tab, right-click, select **Rename** and type in a descriptive name for your worksheet like **Excel for POE 1.2-1.4**, for *Using Excel for Principles of Econometrics, 4e*—sections 1.2 through 1.4. Press the **Enter** key on your keyboard or left-click anywhere on your worksheet.

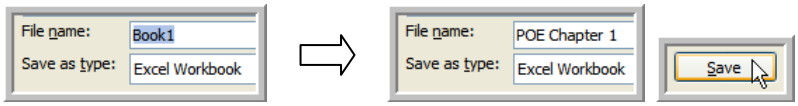


1.5 SAVING AND PRINTING YOUR DATA

All you need to do now is to save your Excel file. Select the **Save** button on the upper left corner of the Excel window.

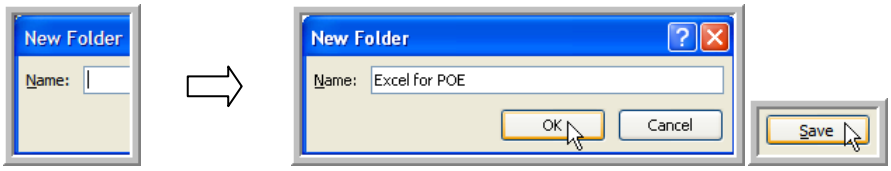
A **Save As** dialog box pops up. Locate the folder you want to save your file in by using the arrow-down located at the extreme right of the **Save in** window or browsing through the list of folders displayed below it.

In the **File name** window, at the bottom of the **Save As** dialog box, the generic name Book1 should be outlined. Type the descriptive name you would like to give to your Excel file, like **POE Chapter 1**. Finally, select **Save**.

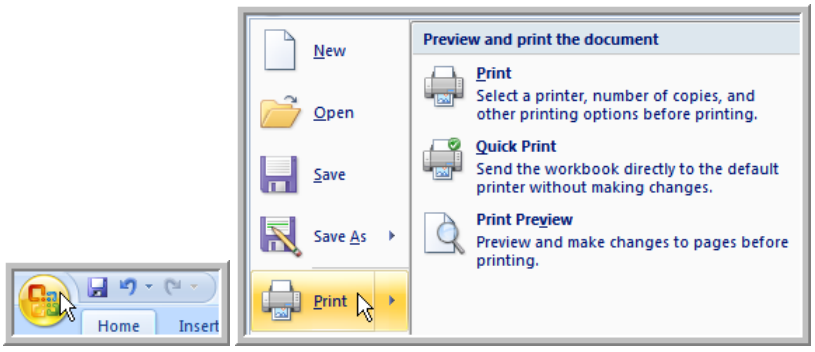


If you need to create a new folder, use the **Create New Folder** button found to the right of the **Save in** window.

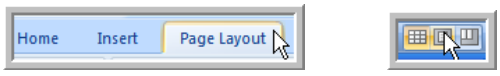
A **New Folder** dialog box pops up; it is prompting you for the name you want to give to your new folder, **Excel for POE** for example. Type it in the **Name** window and select **OK**. Finally, select **Save**.



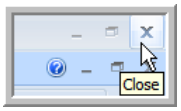
If you would like to print your table, select the **Office Button**, next to the **Save** button; go to **Print**, and select one of the print options.



For more print options, you might want to check out the **Page Layout** tab, on the upper left of your screen, as well as the **Page Layout** button on the bottom right of your screen.



To close your file, select the **X** button on the upper right corner of your screen.



In the next section, we show you how to import data into an Excel spreadsheet. Getting data for economic research is much easier today than it was years ago. Before the Internet, hours would be spent in libraries, looking for and copying data by hand. Now we have access to rich data sources which are a few clicks away.

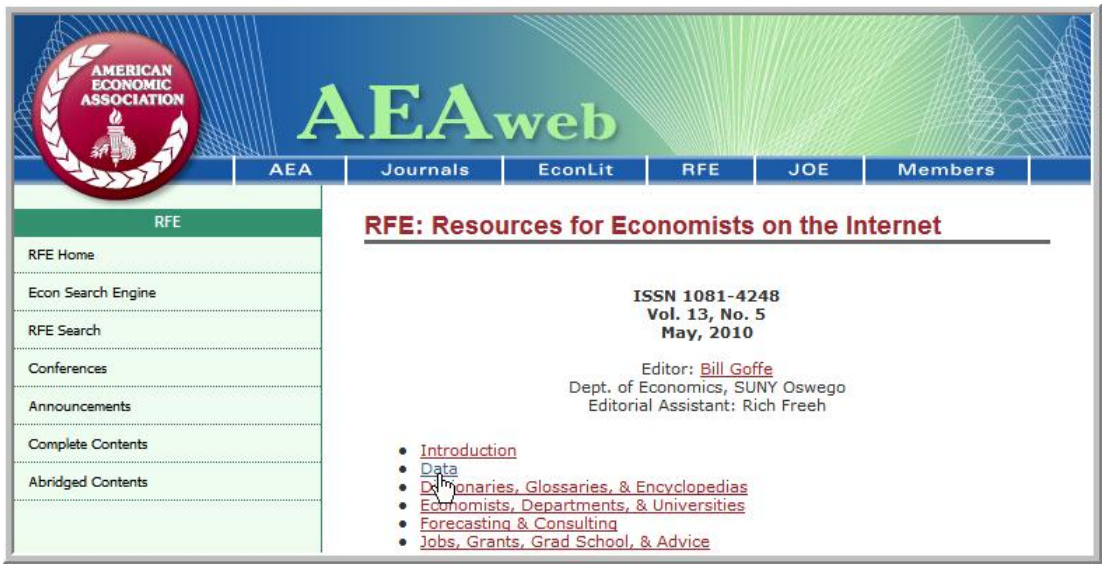
First we will illustrate how convenient sites that make data available in Excel format can be. Then we illustrate how to import ASCII or, text files, into Excel.

1.6 IMPORTING DATA INTO EXCEL

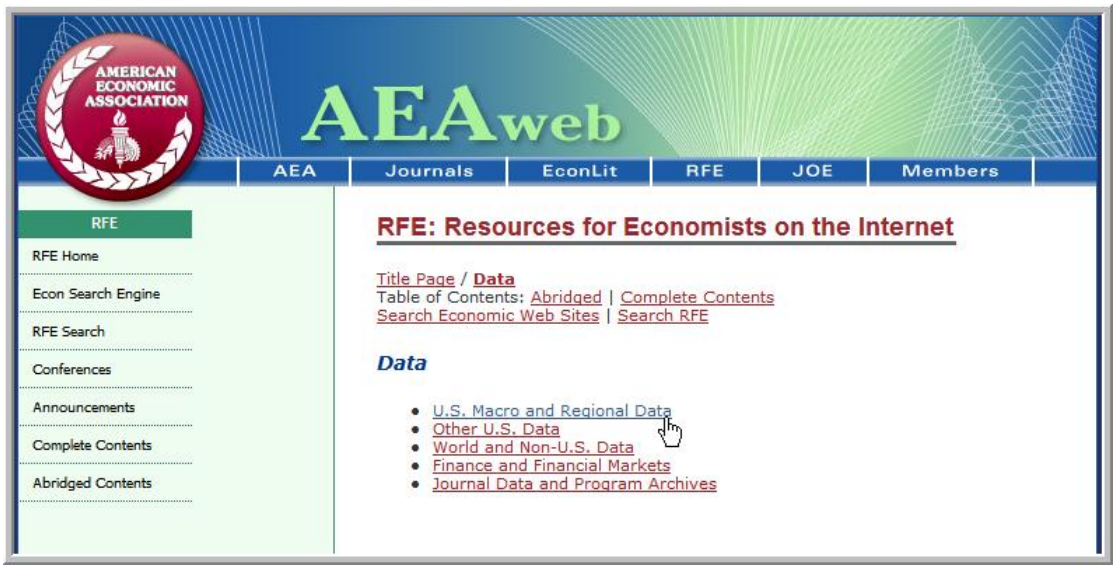
1.6.1 Resources for Economists on the Internet

Suppose you are interested in analyzing the GDP of the United States. The website **Resources for Economists** contains a wide variety of data, and in particular the macro data we seek. Websites are continually updated and improved. We guide you through an example, but be prepared for differences from what we show here.

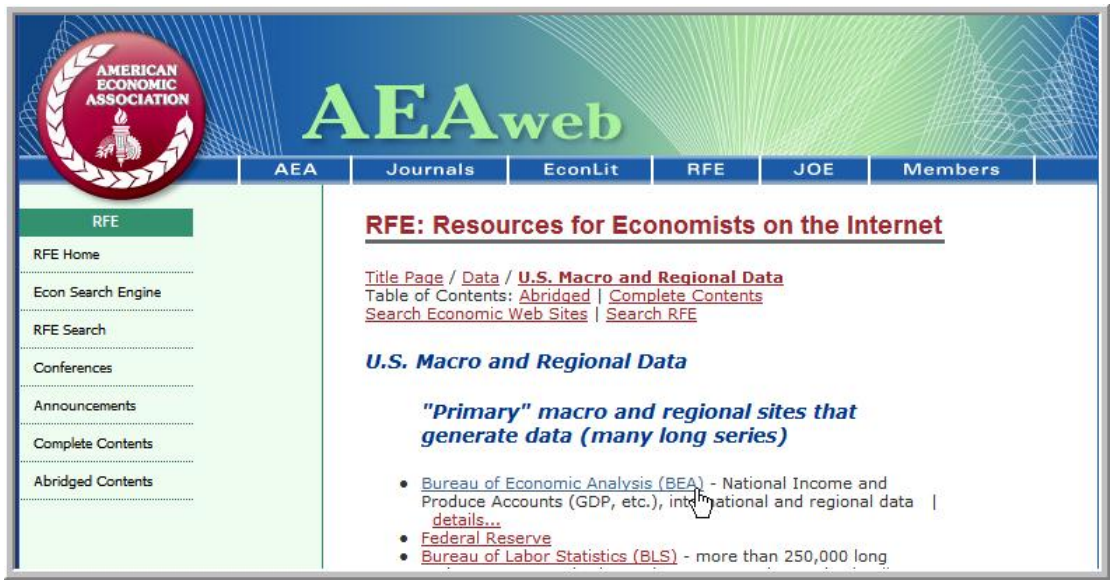
First, open up the website http://rfe.org/.



Select the **Data** link and then select **U.S. Macro and Regional Data**.

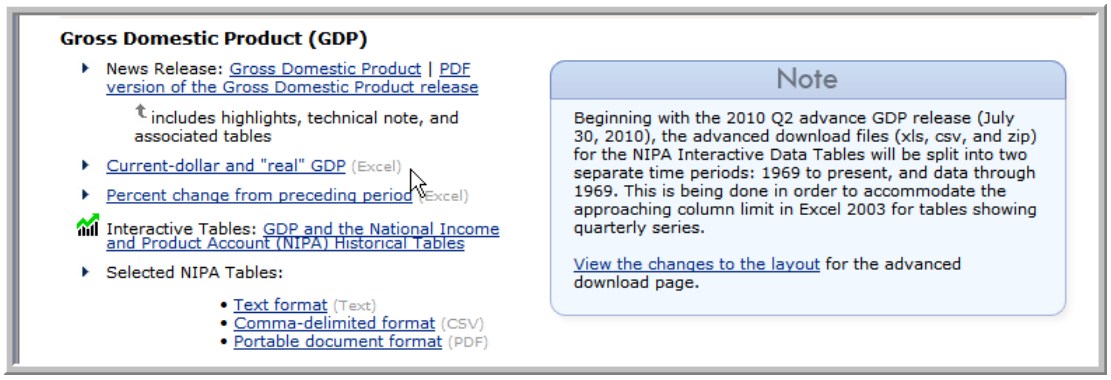


This will open up a range of sub-data categories. For the example discussed here, select the **Bureau of Economic Analysis (BEA).**

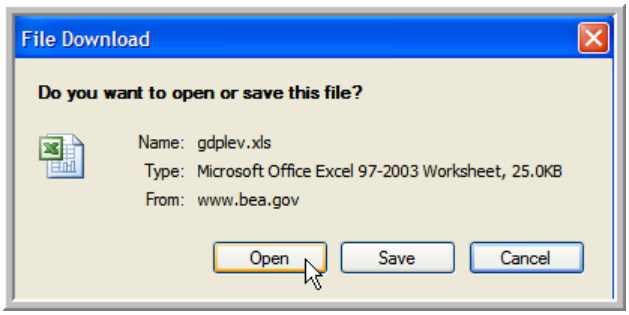


Finally, select **Gross Domestic Product (GDP).**

The result shows the point we are making. Many government and other web sites make data available in **Excel** format. Select **Current-dollar and "real" GDP**.



You have the option of saving the resulting Excel file to your computer or storage device, or opening it right away—which we proceed to do next.



What opens is a workbook with headers explaining the variables it contained. We see that there is a series of annual data and a quarterly series.

	A	B	C	D	E	F	G
1		Current-Dollar and "Real" Gross Domestic Product					
2							
3		Annual				Quarterly	
4						(Seasonally adjusted annual rates)	
5							
6		GDP in billions of current dollars	GDP in billions of chained 2005 dollars			GDP in billions of current dollars	GDP in billions of chained 2005 dollars
7							
8							
9	1929	103.6	977.0		1947q1	237.2	1,772.2
10	1930	91.2	892.8		1947q2	240.4	1,769.5
11	1931	76.5	834.9		1947q3	244.5	1,768.0
12	1932	58.7	725.8		1947q4	254.3	1,794.8
13	1933	56.4	716.4		1948q1	260.3	1,823.4

The opened file is "Read Only" so you must save it under another name to work with it, graph, run regressions and so on.

1.6.2 Data Files for Principles of Econometrics

The book *Principles of Econometrics, 4e*, uses many examples with data. These data files have been saved as workbooks and are available for you to download to your computer. There are about 150 such files. The data files and other supplementary materials can be downloaded from two web locations: the publisher website or the book website maintained by the authors.

1.6.2a John Wiley and Sons Website

Using your web browser, enter the address www.wiley.com/college/hill. Find, among the authors named "Hill", the book *Principles of Econometrics, 4e*.

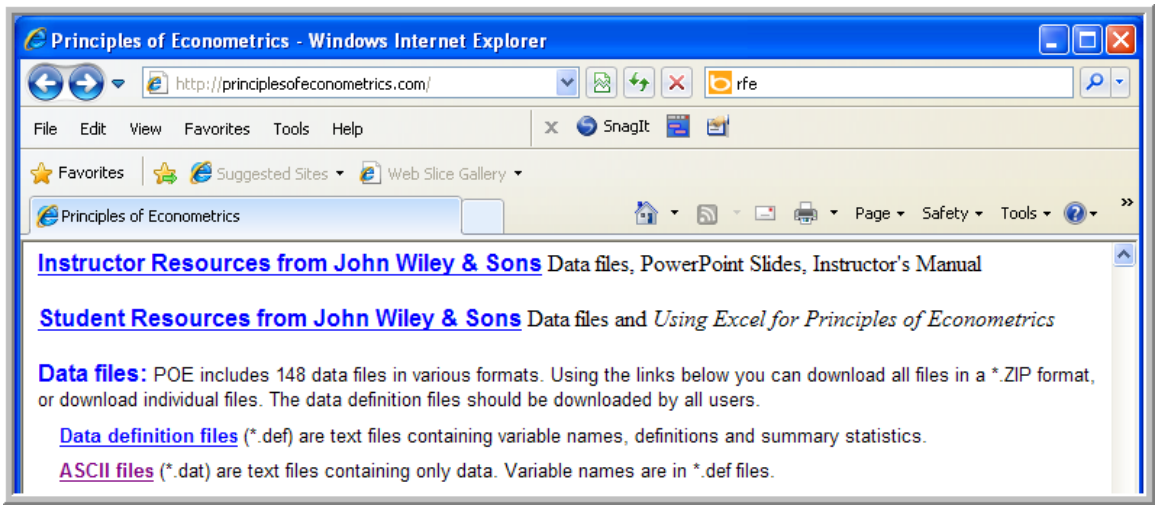
Follow the link to **Resources for Students**, and then **Student Companion Site**. There, you will find links to supplement materials, including a link to **Data Files** that will allow you to download all the data definition files and data files at once.

1.6.2b Principles of Econometrics Website

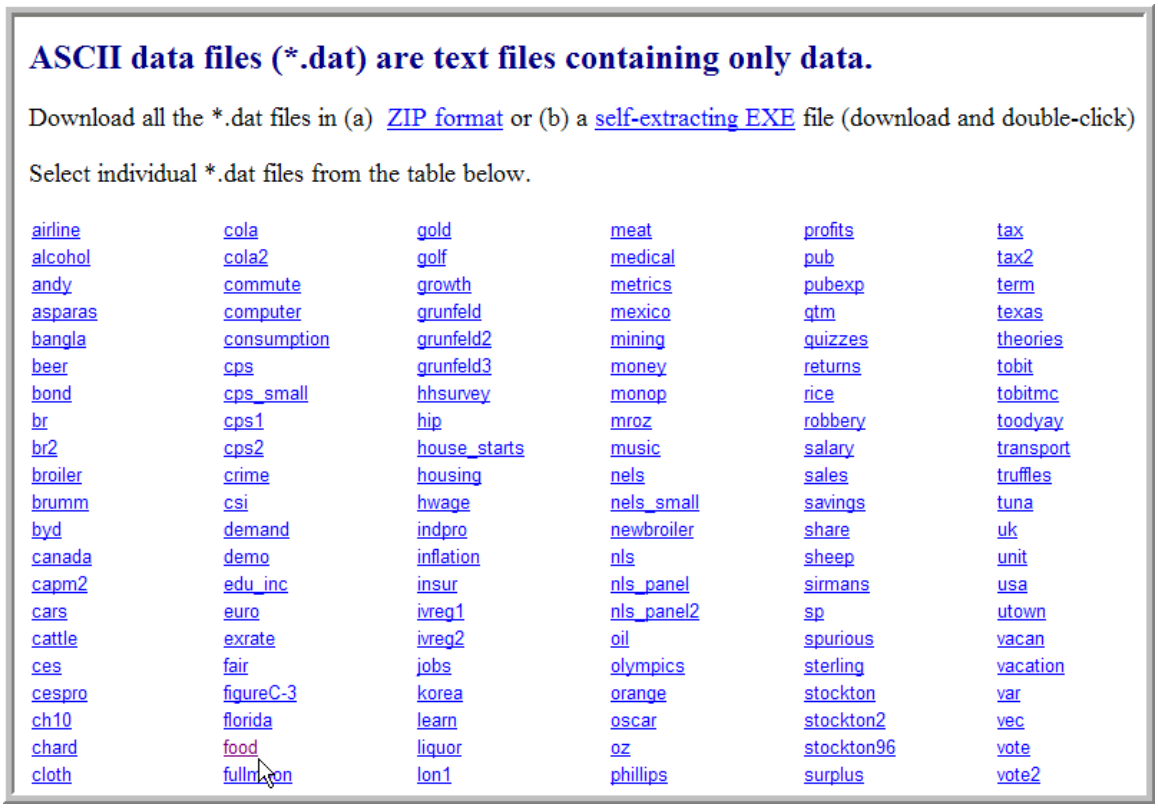
The address for the book website is www.principlesofeconometrics.com. There, you will find links to the Data definitions files, Excel spreadsheets, as well as an Errata list. You can download the data definition files and the Excel files all at once or select individual files. The data definition files contain variable names, variable definitions, and summary statistics. The Excel spreadsheets contain data only; those files were created using Excel 2003.

1.6.3 Importing ASCII Files

Sometimes data that you want to use may be provided but in ASCII or text format. To illustrate go to http://principlesofeconometrics.com. There you will find that one of the formats in which we provide data is ASCII or text files. These are used because they contain no formatting and can be used by almost every software once imported.

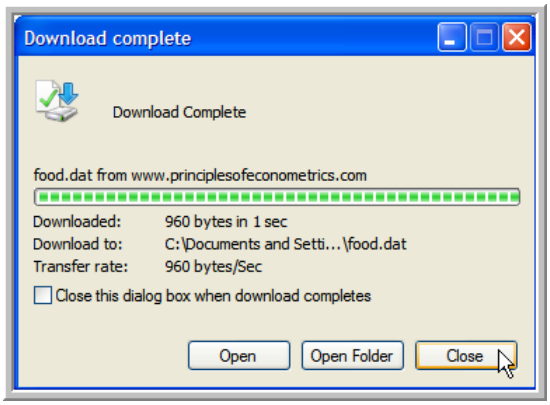


Select **ASCII files** and then go to the **food** data.

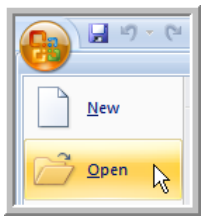


Right-click on the file name. Select **Save Target As**. A **Save As** dialog box pops up. Locate the folder you want to save your file in by using the arrow-down located at the extreme right of the **Save in** window or browsing through the list of folders displayed below it. Finally, select **Save**.

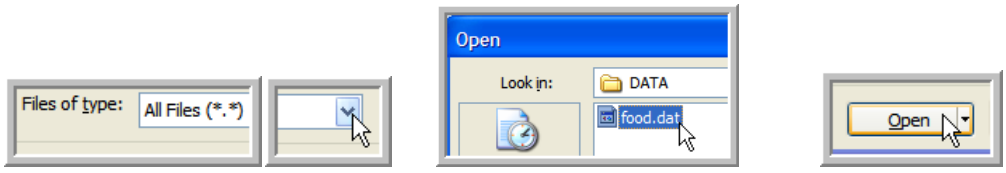
Once the download of the file is completed, a **Download complete** window pops up. Choose **Close**.



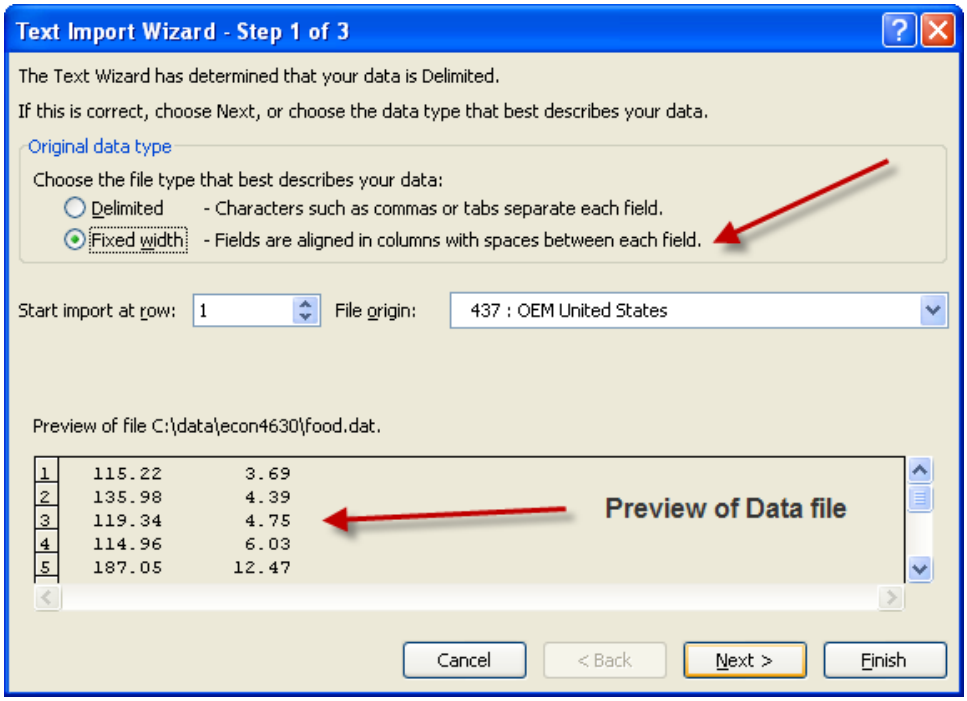
Start Excel. Select the **Office Button** on the upper left corner of the Excel window**,** then **Open.**



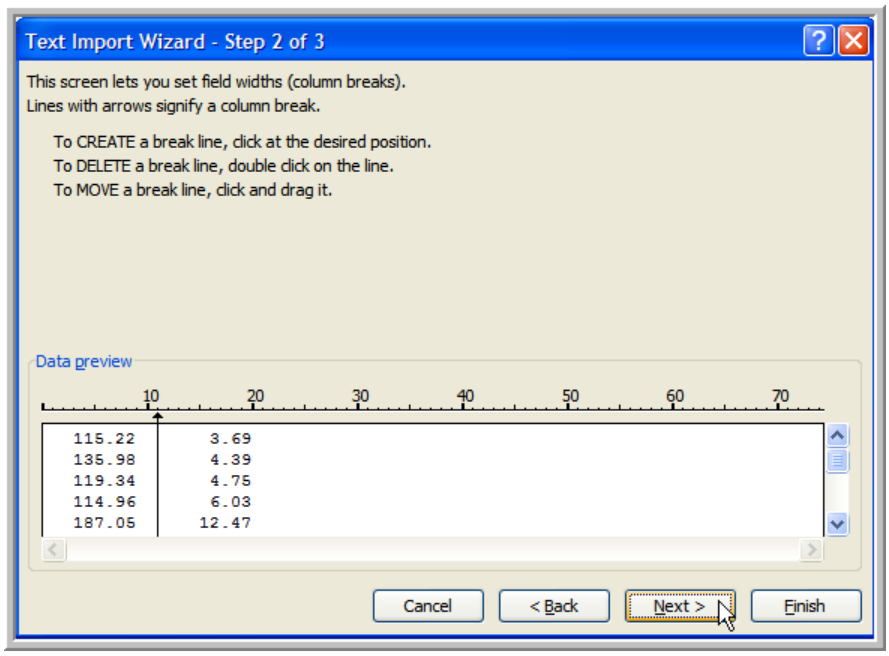
Navigate to the location of the data file. Make sure you have selected **All Files** in the **Files of Type** window. Select you **food.dat** file and then select **Open**.



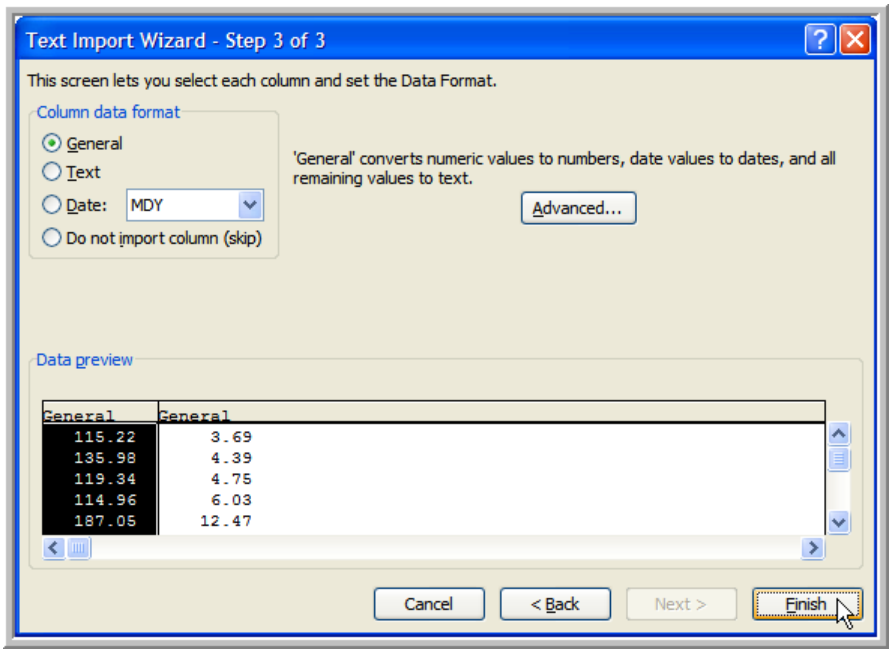
What begins is a Windows "Wizard" that will take you through 3 steps to import the data into Excel. Our ASCII data files are neatly lined up in columns with no commas or anything else separating the columns. Select **Fixed width**, and then **Next**.



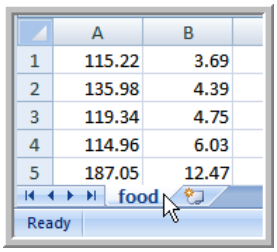
In the next step the data are previewed. By clicking on the vertical black line you could adjust the column width, but there is no need most of the time. For neatly arrayed data like ours, Excel can determine where the columns end and begin. Select **Next** again.



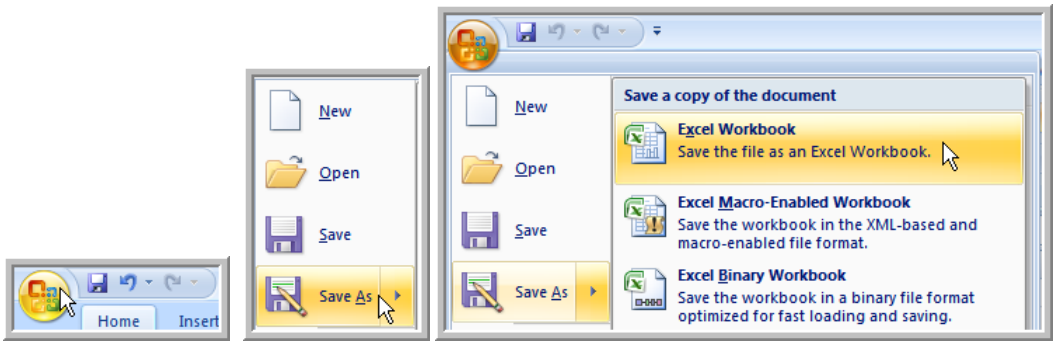
In the third and final step Excel permits you to format each column, or in fact to skip a column. In our case you can simply select **Finish**.



This step concludes the process and now the data is in a worksheet named **food**.

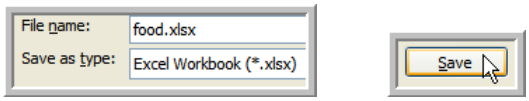


Next, you need to save your food data in an Excel File format. To do that, select the **Office Button**, **Save As**, and finally **Excel Workbook**.



A **Save As** dialog box pops up. Locate the folder you want to save your file in by using the arrow-down located at the extreme right of the **Save in** window or browsing through the list of folders displayed below it.

Excel has automatically given a **File name**, **food.xlsx**, and specify the file format in the **Save as type** window, **Excel Workbook (*.xlsx)**. All you need to do is select **Save**.



From this point you are ready to analyze the data.

This completes our introductory Chapter. The rest of this manual is designed to supplement your readings of *Principles of Econometrics*, *4e*. We will walk you through the analysis of examples found in the text, using Excel 2007. We would like to be able to replicate most of the plots of data and tables of results found in your text.

CHAPTER 2

The Simple Linear Regression Model

CHAPTER OUTLINE

In this chapter we estimate a simple linear regression model of weekly food expenditure. We also illustrate the concept of unbiased estimation. In the first section, we start by plotting the food expenditure data.

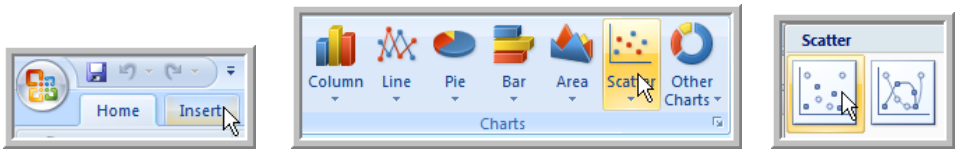
2.1 PLOTTING THE FOOD EXPENDITURE DATA

Open the Excel file ***food***. Save it as **POE Chapter 2**.

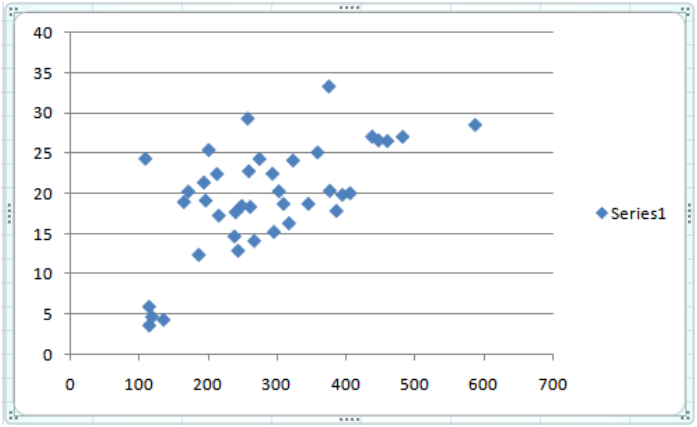
Compare the values you have in your worksheet to the ones found in Table 2.1, p. 49 of *Principles of Econometrics, 4e*. The second part of Table 2.1 shows summary statistics. You can

compute and check on those by using Excel mathematical functions introduced in Chapter 1, if you would like.

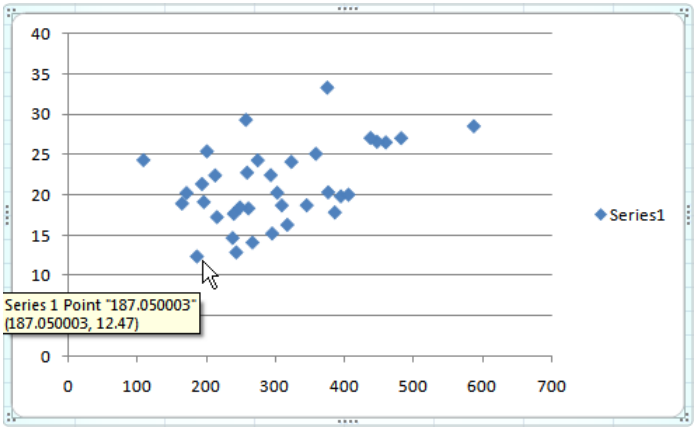
Select the **Insert** tab located next to the **Home** tab. Select **A2:B41**. In the **Charts** groups of commands select **Scatter**, and then **Scatter with only Markers**.



The result is:



Each point on this **Scatter chart** illustrates one household for which we have recorded a pair of values: weekly food expenditure *and* weekly income. This is very important. We *chose* **Scatter chart** because we wanted to keep track of those pairs of values. For example, the point highlighted below illustrates the pair of values $(187.05, 12.47)$ found in row 6 of your table.

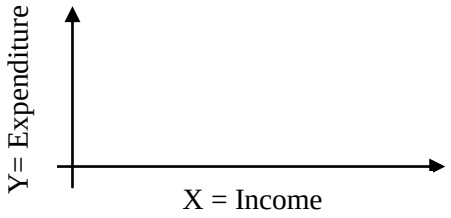


When we select two columns of values to plot on a **Scatter chart**, Excel, by default, represents values from the *first column on the horizontal axis* and values from the *second column on the vertical axis*. So, in this case, the expenditure values are illustrated on the horizontal axis and income values on the vertical axis. Indeed, you can see that the scale of the values on the

horizontal axis corresponds to the one of the food expenditure values in column **A**, and the scale of the values on the vertical axis corresponds to the one of the income values in column **B**.

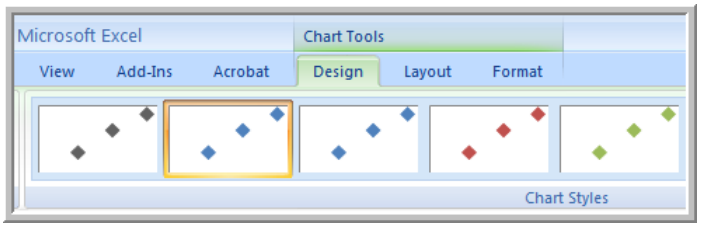
We actually would like to illustrate the food expenditure values on the vertical axis and the income values on the horizontal axis—opposite of what it is now. By convention, across disciplines, the variable we monitor the level of (the dependent variable) is illustrated on the vertical axis (Y-variable). And by convention, across disciplines, the variable that we think might explain the level of the dependent variable is illustrated on the horizontal axis (X-variable).

In our case, we think that the variation of levels of income across households might explain the variation of levels of food expenditure across those same households. That is why we would like to illustrate the food expenditure values on the vertical axis and the income values on the horizontal axis.

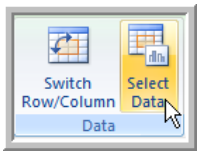


2.1.1 Using Chart Tools

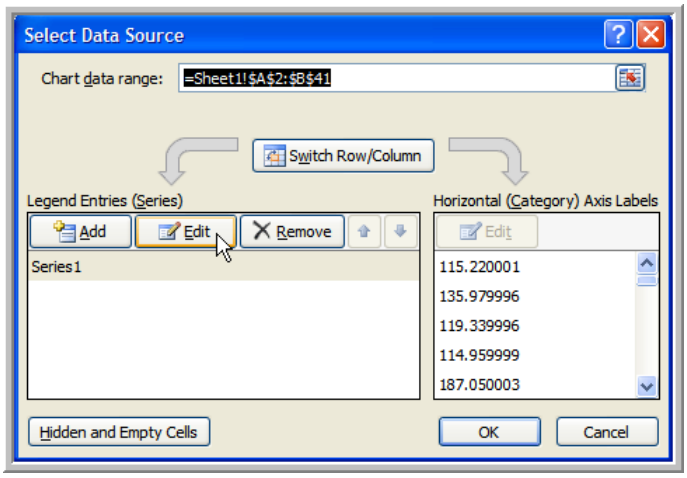
If you look up on your screen, to the right end of your tab list, you should notice that **Chart Tools** are now displayed, adding the **Design**, **Layout**, and **Format** tabs to the list. The **Design** tab is open. (If, at any time, the **Chart Tools** and its tabs seem to disappear, all you need to do is to put your cursor anywhere in your Chart area, left-click, and they will be made available again.)



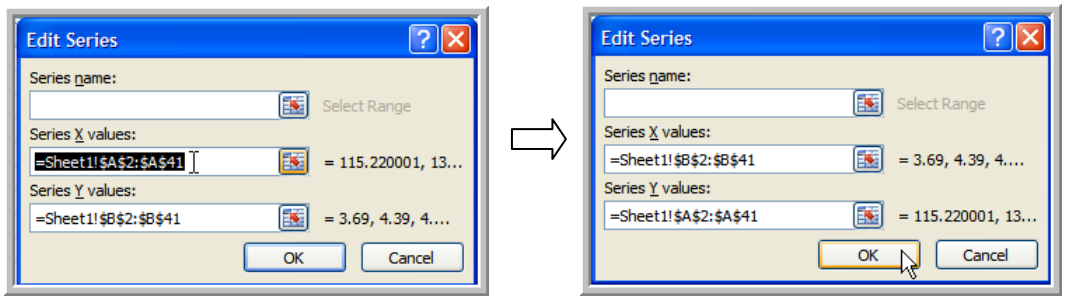
Go to the **Data** group of commands, to the left, and select the **Select Data** button.



A **Select Data Source** dialog box pops up. Select **Edit**.

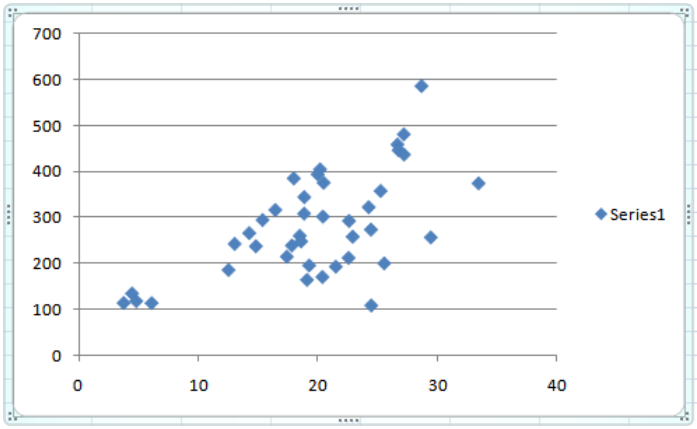


In the **Edit Series** dialog box, highlight the text from the **Series X values** window. Press the **Delete** key on your keyboard. Select **B2:B41**. Highlight and delete the text from the **Series Y values** window. Select **A2:A41**. Select **OK**.



The **Select Data Source** dialog box reappears. Select **OK** again. You have just told Excel that income are the X-values, and food expenditure are the Y-values—not the other way around.

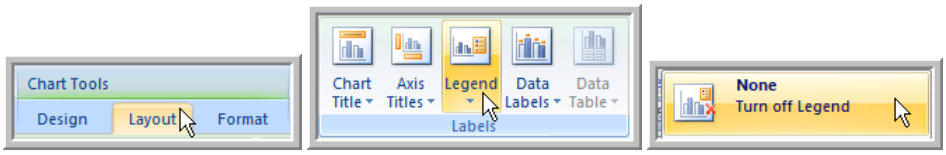
The result is:



2.1.2 Editing the Graph

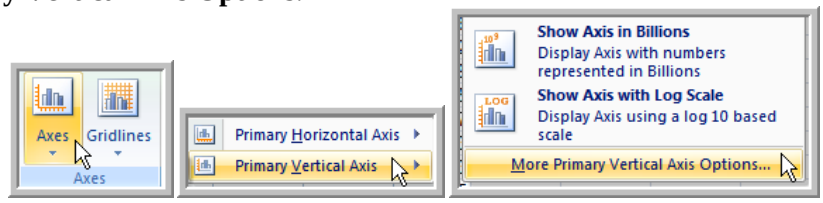
Now, we would like to do some editing. We do not need a **Legend**, since we have only one data series. Our expenditure values do not go over 600, so we can restrict our vertical axis scale to that. We definitely would like to label our axes. We might want to get rid of our **Gridlines**, and change the **Format** of our data series. Finally, we would like to move our chart to a new worksheet.

Select the **Layout** tab. On the **Labels** group of commands, select **Legend** and **None** to delete the legend.

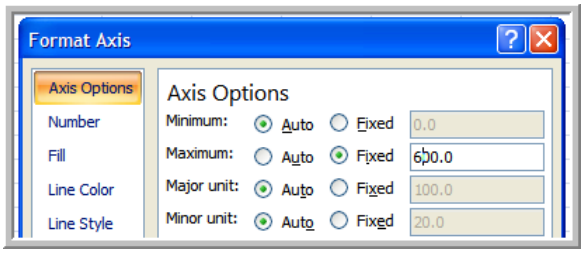


2.1.2a Editing the Vertical Axis

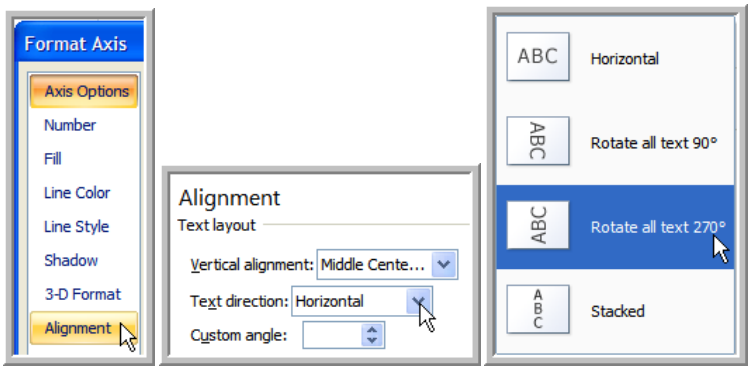
Select the **Axes** button on the **Axes** group of commands. Go to **Primary Vertical Axis**, and select **More Primary Vertical Axis Options**.



A **Format Axis** dialog box pops up. Change the **Maximum** value illustrated on the axis from **Auto** to **Fixed**, and specify **600**.



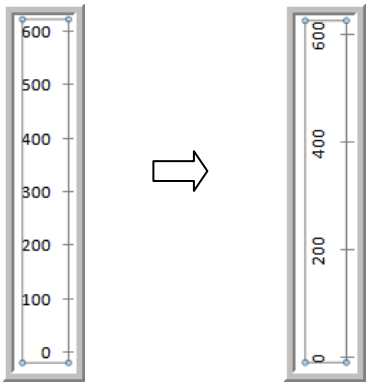
Next select **Alignment**, and use the arrow-down in the **Text direction** window to select **Rotate all text 270°**.



Place your cursor on the upper blue border of your **Format Axis** dialog box.

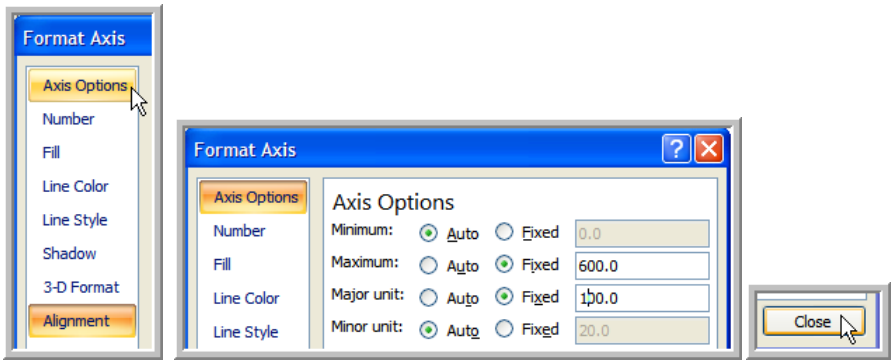
Left-click, hold it, and drag the box over so you can see your chart; release. Look at the vertical axis of your chart.

The numbers are now displayed vertically instead of horizontally, but less of them are displayed as well:



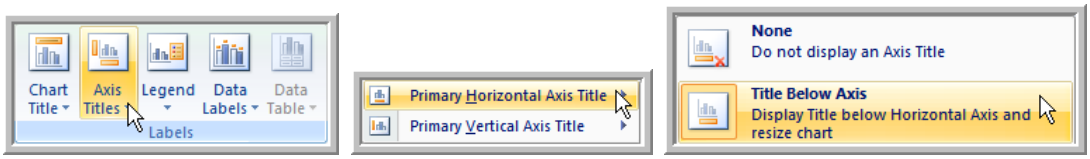
We want to change that back.

Select **Axis Options** again. Change **Major unit** from **Auto** to **Fixed**, and specify **100**. Select **Close**.



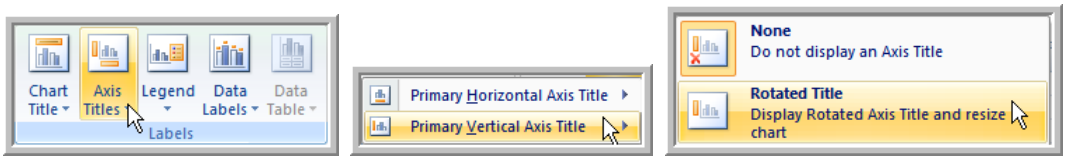
2.1.2b Axis Titles

Back to the **Labels** group of commands; select **Axis Titles**, go to **Primary Horizontal Axis Title**, and select **Title Below Axis**.

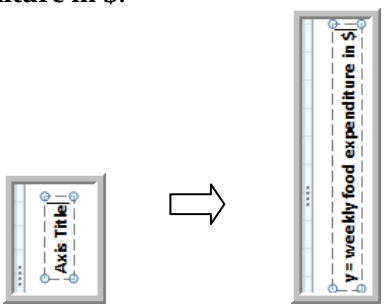


Select the generic **Axis Title** in the bottom of your chart and type in **x = weekly income in $100**.

Go back to **Axis Titles**, then to **Primary Vertical Axis Title** this time. Select **Rotated Title**.

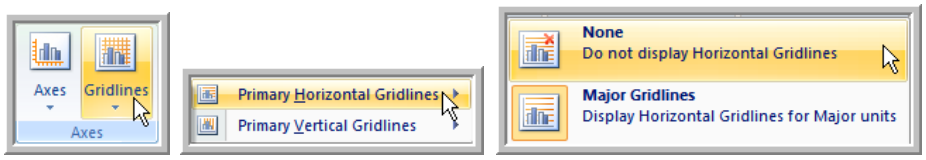


Select the generic **Axis Title** on the left of your chart and press **Delete**, or put your cursor on top of the **Axis Title** box, left-click, and press the **Backspace** key to delete the generic **Axis Title**. Type in **y = weekly food expenditure in $**.

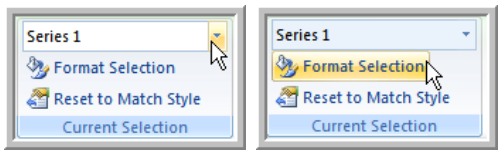


2.1.2c Gridlines and Markers

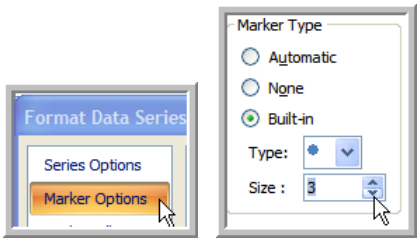
Back to the **Axes** group of commands now. Select **Gridlines**. Go to **Primary Horizontal Gridlines**, and select **None**.



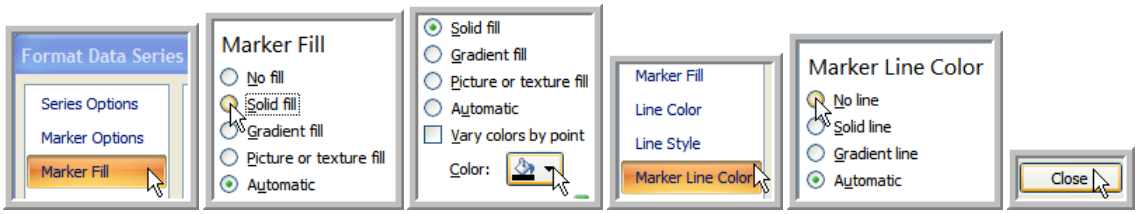
Change the **Current Selection** (group of commands to the far left) to **Series 1** (use the arrow down button to the right of the window to make that selection). Select **Format Selection**.



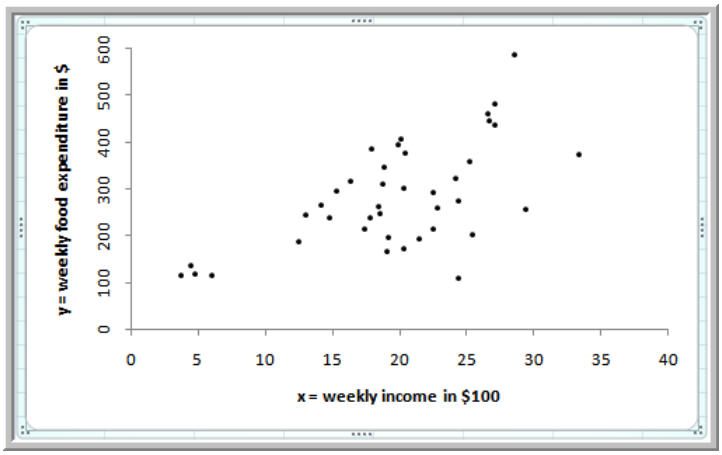
A **Format Data Series** dialog box pops up. Select **Marker Options**. Change the **Marker Type** from **Automatic** to **Built-in**. Change the **Type** and the **Size** as shown below:



Next, select **Marker Fill**. Change it from **Automatic** to **Solid fill**. **Color** options pop up. Change the **Color** to black. Select **Marker Line Color**, and change it from **Automatic** to **No line**. Select **Close**.

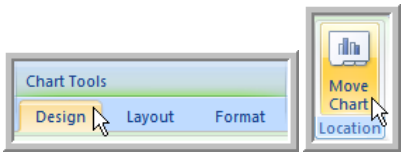


The result is a replica of Figure 2.6 p. 50 in *Principles of Econometrics, 4e*: (if it looks like some of your dots are little flowers, left–click your cursor anywhere on your screen first)

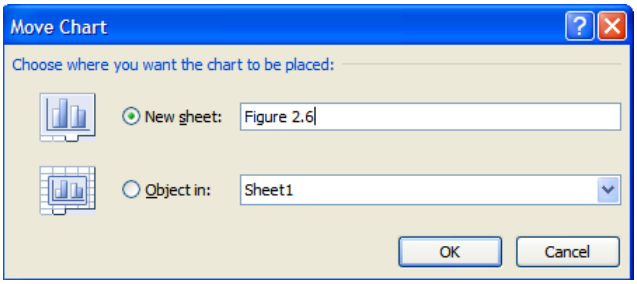


2.1.2d Moving the Chart

Go back to the **Design** tab. (Remember if you don't see your **Chart Tools** tabs, what you need to do is place your cursor in your chart area and left-click). Select the **Move Chart** button on the **Location** group of commands to the far right of your screen.



A **Move Chart** dialog box pops up. Select **New sheet** and give it a name like **Figure 2.6**. Select **OK**.



Rename Sheet 1 **Data** (if needed, see Section 1.4 of this manual on how to do that).

We have plotted our data, and edited our chart. Next, we want to estimate the regression line that best fit the data, and add this line to the chart.

2.2 ESTIMATING A SIMPLE REGRESSION

In this section, we are going to use two different methods to obtain the least squares estimates of the intercept and slope parameters β_1 and β_2. Method 1 consists of plugging in values into the b_1 and b_2 least squares estimators' formulas. Method 2 consists of making use of Excel built-in regression analysis routine.

2.2.1 Using Least Squares Estimators' Formulas

The least squares estimators are:

$$b_2 = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2} \tag{2.1}$$

$$b_1 = \bar{y} - b_2\bar{x} \tag{2.2}$$

These formulas are telling us two things: (1) which values we need, and (2) how we need to combine them to compute b_1 and b_2.

(1) *Which values do we need?*

We need the (x_i, y_i) pairs of values—they do appear explicitly in equation (2.1). We also need $\bar{x}$ and $\bar{y}$, which are the sample means, or simple arithmetic averages of the x_i values and y_i values—those averages appear both in equation (2.1) and equation (2.2). Note that the subscript i in x_i and y_i keeps count of the x and y values. In other words, i denotes the *i*th value or *i*th pair of values. Also, $\bar{x}$ and $\bar{y}$, are referred to as "x-bar" and "y-bar".

(2) *How do we combine those values?*

Equation (2.1): $b_2 = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{\Sigma(x_i - \bar{x})^2}$

The *numerator* is the sum of products; Σ is the Greek capital letter "sigma" which denotes sum. The first term of each product is the deviation of an x value from its mean $(x_i - \bar{x})$. The second term of each product is the deviation of the *corresponding* y value from its mean $(y_i - \bar{y})$. The products are computed for each (x_i, y_i) pair of values before they are added together.

The *denominator* is the sum of the squared deviations from the mean, for the x values only. In other words, each x value deviation from its mean is first squared, and then all those squared deviations values are summed.

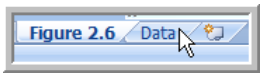
Equation (2.2): $b_1 = \bar{y} - b_2\bar{x}$

This equation tells us to multiply b_2 by $\bar{x}$, and then subtract this product from $\bar{y}$. Note that b_2 must be computed first—before b_1 can be computed.

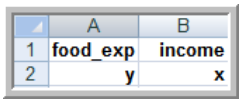
There is actually no magic to this. We use the food expenditure and income values we have collected from our random sample of 40 households, and perform *simple* arithmetic operations to compute the estimates the intercept and slope coefficient of our regression line.

As for the computation of b_1 and b_2 itself, there is only one trick. We need to make sure we know which values are the x's and which ones are the y's. So, we are going to start by adding labels to our columns of data.

You should be in your **Data** worksheet. If not, you can go back to it by selecting its tab on the bottom of your screen.

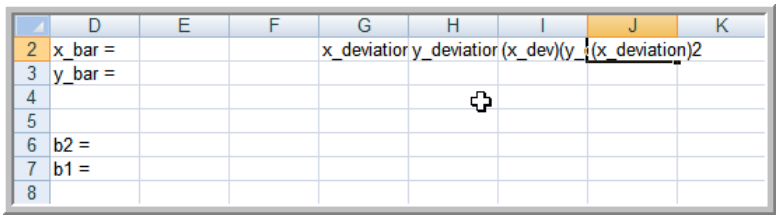


Select **row 2** and insert a new row (see Section 1.4 of this manual if you need help on that). In the new cell **A2**, type **y**; and in the new cell **B2**, type **x**. **Right-align A1:B2**.



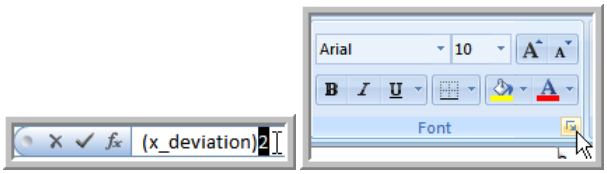
	A	B
1	food_exp	income
2	y	x

Next, we need to lay out the frame of the table where we are going to store our intermediate and final computations. Type **x_bar =** in cell **D2**, **y_bar =** in cell **D3**, **b2 =** in cell **D6**, and **b1 =** in cell **D7**. In cell **G2:J2**, type **x_deviation**, **y_deviation**, **(x_dev)(y_dev)**, and **(x_deviation)2**, respectively. (Note that you can use your **Tab key**, instead of moving your cursor or using the **Arrow key**, to move to the next cell to your right).

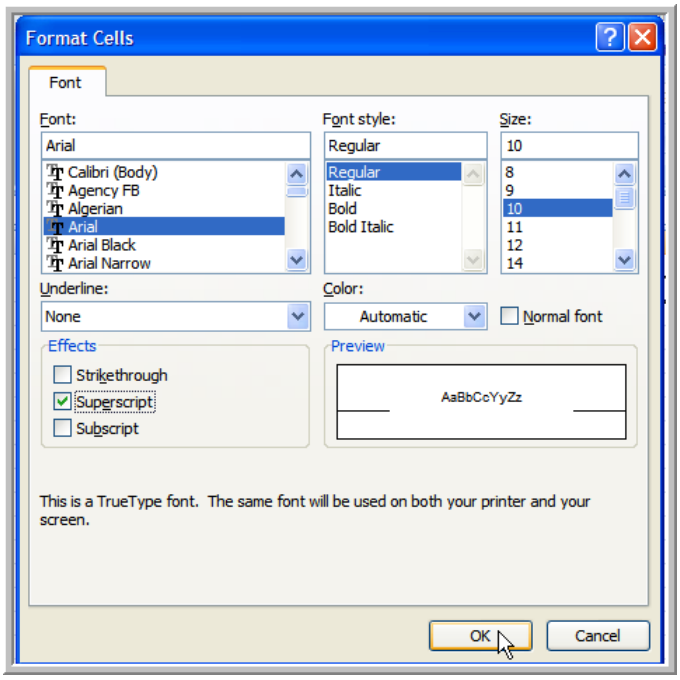


Below **x_deviation** we are going to compute and store the deviations of the x values from their mean. Below **y_deviation**, we are going to compute and store the deviations of the y values from their mean. Below **(x_dev)(y_dev)**, we are going to compute and store the products of the x deviation and the y deviation for each pair of values. Finally, below **(x_deviation)2** we are going to compute and store the x deviations squared.

To show the **2** of **(x_deviation)2** as a square, place your cursor in **J2**, if it is not already in it. Move to the **Formula bar** to select the **2**, and select the arrow to the right corner of the **Font** group of commands.



A **Format cells** dialog box pops up. Select **Superscript** and then **OK**.



In cells **D6** and **D7** proceed to format the **2** and **1** of b_2 and b_1 as **Subscript**s instead. **Bold** all the labels you just typed, and **Align Right** the ones from **G2:J2**. Finally, resize the width of columns **G:J** to accommodate the width of its labels (see Section 1.4 of this manual if you need help on that).

Now, your worksheet should look like this one:

	D	E	F	G	H	I	J
2	**x_bar =**			**x_deviation**	**y_deviation**	**(x_dev)(y_dev)**	**(x_deviation)^2**
3	**y_bar =**						
4							
5							
6	**b_2 =**						
7	**b_1 =**						

We have computed averages before. The formula you should have in cell **E2** is **=AVERAGE(B3:B42)**, and the one in cell **E3** is **= AVERAGE(A3:A42)**. Compare the averages you get to the sample means of Table 2.1 in *Principles of Econometrics*, *4e* (p. 49); they should be the same.

	D	E	F	G	H	I	J
2	**x_bar =**	19.60475		**x_deviation**	**y_deviation**	**(x_dev)(y_dev)**	**(x_deviation)^2**
3	**y_bar =**	283.5735					
4							
5							
6	**b_2 =**						
7	**b_1 =**						

Next, we want to compute the deviations. Think about what you are trying to compute. And then type the needed formulas in **G3:J3**.

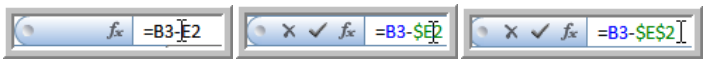
You should type **=B3 – E2** in cell **G3**, **=A3 – E3** in cell **H3**, **=G3*H3** in cell **I3**, and **G23^2** in cell **J3**. Here are the values you should get:

	D	E	F	G	H	I	J
2	**x_bar =**	19.60475		**x_deviation**	**y_deviation**	**(x_dev)(y_dev)**	**(x_deviation)^2**
3	**y_bar =**	283.5735		-15.9147501	-168.353498	2679.303845	253.2792692
4							
5							
6	**b_2 =**						
7	**b_1 =**						

Now, in cells **G3** and **H3**, we gave cell references **E2** and **E3,** where the averages are stored. Note that we will need to use those averages again, and get those averages from these same exact locations, to compute the deviations of the next 39 observations.

So, what we actually need to do is to transform these **Relative cell references** (**E2** and **E3**) into **Absolute cell references** (**$E$2** and **$E$3**). This will allow us to copy the formula from **G3:H3** down below without losing track of the fact that the values for the averages are stored in cells **E2** and **E3**.

A **Relative cell reference** is made into an **Absolute cell reference** by preceding both the row and column references by a dollar sign. Place your cursor back in cell **G3** (i.e. move your mouse over and left-click); in the **Formula bar**, place your cursor before the **E** and insert a dollar sign (press the **Shift-key** and the **$ key** at the same time); move your cursor before the **2** and insert another dollar sign; place your cursor at the end of the formula and press **Enter**.



Go to cell **H3**, and add the needed dollar signs there too. Now, you can select **G3:J3**. Select **Copy** on the **Clipboard** group of command. Select **G4:J42**, and select **Paste** (next to **Copy**). You have just copied the formulas to compute the needed deviations for the rest of the (x_i, y_i) pairs.

Your worksheet should look like this:

	D	E	F	G	H	I	J
2	**x_bar =**	19.60475		**x_deviation**	**y_deviation**	**(x_dev)(y_dev)**	**$(x\_deviation)^2$**
3	**y_bar =**	283.5735		-15.9147501	-168.353498	2679.303845	253.2792692
4				-15.2147501	-147.593503	2245.598261	231.4886191
5				-14.8547501	-164.233503	2439.647641	220.663599
6	**b_2 =**			-13.5747501	-168.6135	2288.886121	184.2738389
7	**b_1 =**			-7.13475005	-96.5234963	688.6710199	50.90465828

We have everything we need to finalize the computation of b_1 and b_2.

Place your cursor in cell **E6**, and again think about what you need to compute b_2. Recall that the least squares estimators are:

$$b_2 = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2} \tag{2.1}$$

$$b_1 = \bar{y} - b_2\bar{x} \tag{2.2}$$

If you refer back to equation (2.1), you can see that **=SUM(I3:I42)/SUM(J3:J42)** is the formula you need in cell **E6**. The one you need in cell **E7** is **=E3 – E6*E2** for equation (2.2).

Your worksheet should look like this:

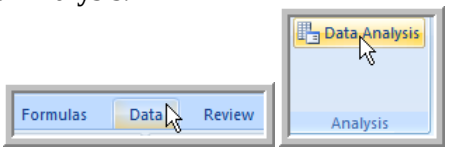
	A	B	C	D	E	F	G	H	I	J
2	**y**	**x**		**x_bar =**	19.60475		**x_deviation**	**y_deviation**	**(x_dev)(y_dev)**	**$(x\_deviation)^2$**
3	115.22	3.69		**y_bar =**	283.5735		-15.9147501	-168.353498	2679.303845	253.2792692
4	135.98	4.39					-15.2147501	-147.593503	2245.598261	231.4886191
5	119.34	4.75					-14.8547501	-164.233503	2439.647641	220.663599
6	114.96	6.03		**b_2 =**	10.20964		-13.5747501	-168.6135	2288.886121	184.2738389
7	187.05	12.47		**b_1 =**	83.41601		-7.13475005	-96.5234963	688.6710199	50.90465828

In the table above we obtain the same exact least squares estimates as those reported on p. 53 of *Principles of Econometrics, 4e*.

That was Method 1 of obtaining the least squares estimates of the intercept and slope parameters β_1 and β_2. For Method 2, we are going to use the Excel built-in regression analysis routine.

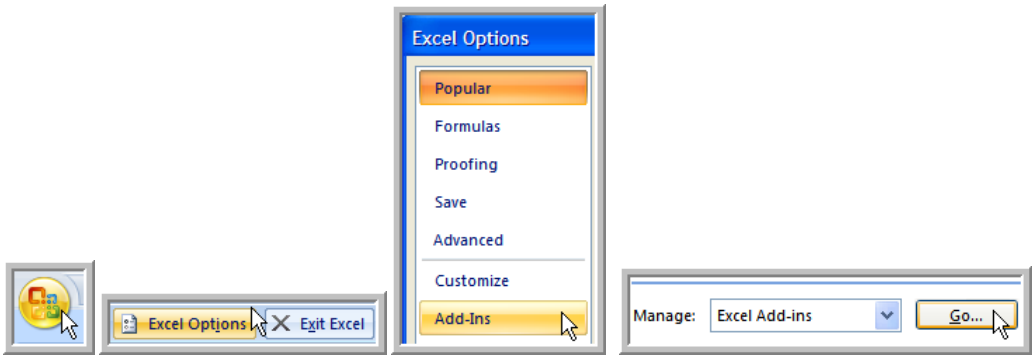
2.2.2 Using Excel Regression Analysis Routine

Select the **Data** tab, in the middle of your tab list. On the **Analysis** group of commands to the far right of the ribbon, select **Data Analysis**.

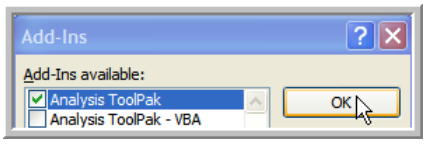


If the **Data Analysis** tool does not appear on the ribbon, you need to load it first.

Select the **Office Button** in the upper left corner of your screen, **Excel Options** on the bottom of the **Office Button** tasks panel, **Add-Ins** in the **Excel Options** dialog box, **Excel Add-ins** in the **Manage** window at the bottom of the **Excel Options** dialog box, and then **Go**.

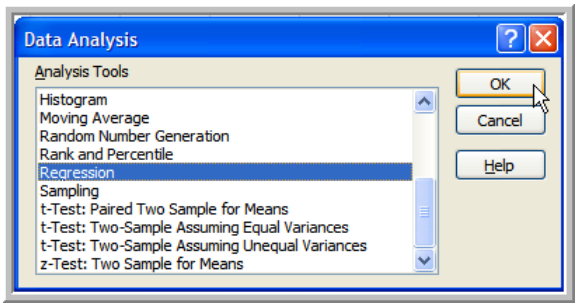


In the **Add-Ins** dialog box, check the box in front of **Analysis ToolPak**. Select **OK**.

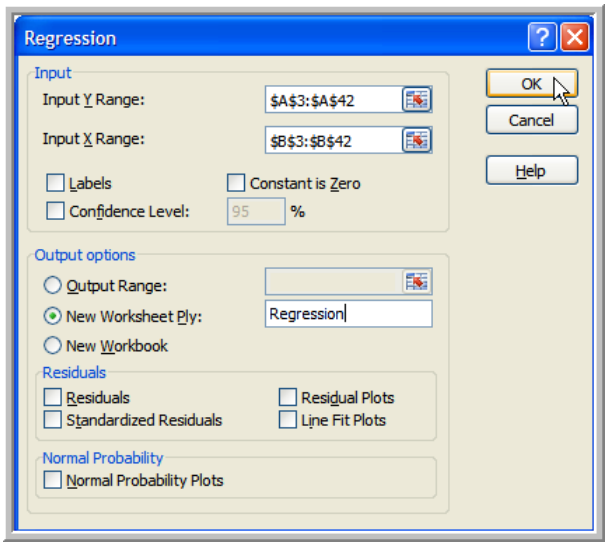


Now **Data Analysis** should be available on the **Analysis** group of commands. Select it.

A **Data Analysis** dialog box pops up. In it, select **Regression** (you might need to use the scroll up and down bar to the right of the **Analysis Tools** window to find it), then select **OK**.



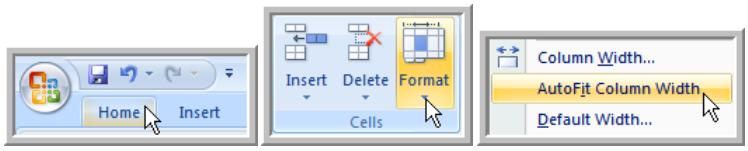
The **Regression** dialog box that pops up next is very similar to the **Edit Series** box we encountered before (see Section 2.1.1). Place your cursor in the **Input Y Range** window, and select **A3:A42** to specify the *y*-values you are working with. Similarly, place your cursor in the **Input X Range** window, and select **B3:B42** to specify the *x*-values you are working with. Next, place your cursor in the **New Worksheet Ply** window and type **Regression**—this is going to be the name of the new worksheet where Excel regression analysis results are going to be stored. Select **OK**.



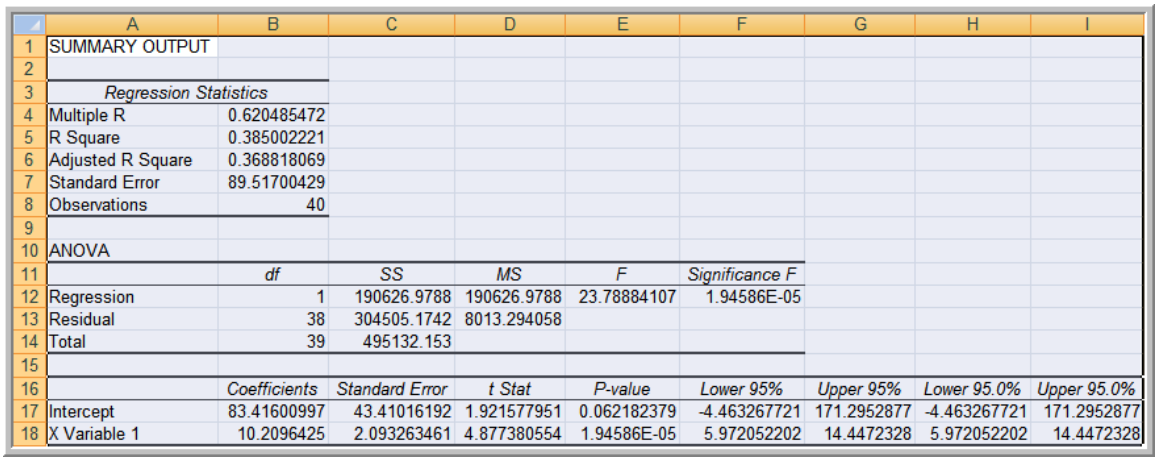
The **Summary Output** that Excel just generated should be highlighted as shown below:

	A	B	C	D	E	F	G	H	I	J
1	SUMMARY OUTPUT									
2										
3	*Regression Statistics*									
4	Multiple R	0.620485								
5	R Square	0.385002								
6	Adjusted F	0.368818								
7	Standard E	89.517								
8	Observatio	40								
9										
10	ANOVA									
11		*df*	*SS*	*MS*	*F*	*ignificance F*				
12	Regressior	1	190627	190627	23.78884	1.95E-05				
13	Residual	38	304505.2	8013.294						
14	Total	39	495132.2							
15										
16		*Coefficients*	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*	
17	Intercept	83.41601	43.41016	1.921578	0.062182	-4.46327	171.2953	-4.46327	171.2953	
18	X Variable	10.20964	2.093263	4.877381	1.95E-05	5.972052	14.44723	5.972052	14.44723	
19										
20										
21										
22										

Select the **Home** tab. In the **Cells** group of commands, select **Format**, and **AutoFit Column Width**; this is an alternative to adjust the width of the selected columns to fit their contents.



Your worksheet should now look like this:



	A	B	C	D	E	F	G	H	I
1	SUMMARY OUTPUT								
2									
3	*Regression Statistics*								
4	Multiple R	0.620485472							
5	R Square	0.385002221							
6	Adjusted R Square	0.368818069							
7	Standard Error	89.51700429							
8	Observations	40							
9									
10	ANOVA								
11		*df*	*SS*	*MS*	*F*	*Significance F*			
12	Regression	1	190626.9788	190626.9788	23.78884107	1.94586E-05			
13	Residual	38	304505.1742	8013.294058					
14	Total	39	495132.153						
15									
16		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
17	Intercept	83.41600997	43.41016192	1.921577951	0.062182379	-4.463267721	171.2952877	-4.463267721	171.2952877
18	X Variable 1	10.2096425	2.093263461	4.877380554	1.94586E-05	5.972052202	14.4472328	5.972052202	14.4472328

The least squares estimates are given under the **Coefficients** column in the last table of the **Summary Output**. The estimate for the **Intercept** coefficient or b_1 is the first one; followed by the estimate of the slope coefficient (**X variable 1** coefficient) or b_2. The summary output contains many other items that we will learn about shortly. For now, notice that the number of **observations** or pairs of values, 40, is given in cell **B8**.

A convenient way to report the values for b_1 and b_2 is to write out the equation of the estimated regression line:

$$\hat{y}_i = 83.42 + 10.21x_i \tag{2.3}$$

Now that we have the equation of our straight line, we would like to graph it. This is what we are doing in the next section.

2.3 PLOTTING A SIMPLE REGRESSION

There are different ways to draw a regression line. One way is to plot two points and draw the line that passes through those two points—this is the method we are going to use first. Another way is plot many points, and then draw the line that passes through all those points—this is the method that Excel uses in its built-in features we are going to look at next.

2.3.1 Using Two Points

When we draw a line by hand, on a piece of paper, using a pen and a ruler, we can use *any* two points. We can extend our line between the points, as well as beyond the points, up and down, or right and left. Excel does not use a ruler. Instead, it uses the coordinates of two points to draw a line, and it draws the line *only* between them. So, to have Excel draw a line that spans over the whole range of data we have, we need to choose those two points a little bit more strategically than usual.

If you look back at your scatter chart (**Figure 2.6** worksheet) or back in your table (**Data** worksheet), you can see that our x values range from about 0 to 35 (from 3.69 to 33.4 exactly). So, we choose our first point to have an x value equal to 0, and our second point an x value of 35.

The point with an x value of zero is our y intercept. It is the point where the line crosses the vertical axis. Its coordinates are $x = 0$ and $y = b_1$ or $(0, 83.42)$. This is our first point.

For our second point, we let $x = 35$; plug this x value in equation (2.3), and compute its corresponding or predicted y value. We obtain:

$$\hat{y} = 83.42 + 10.21(35) = 440.77 \tag{2.4}$$

This is our second point, with coordinates $(35, 440.77)$.

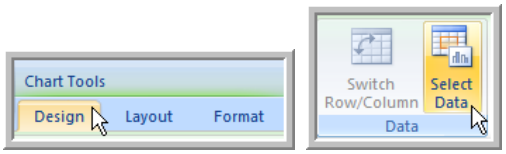
Go back to your **Data** worksheet (if you are not already there). In cell **L1**, type **Points to graph regression line**. In columns **L** and **M** we are going to record the coordinates of the two points we are using to draw our regression line. In cell **L2**, type **y**; in cell **M2**, type **x**. In cell **M3**, type **0**; in cell **M4**, type **35**. In cell **L3**, we actually want to record the value for our y intercept or b_1, which we already have in cell **E7**. So, we are going to get it from there: in cell **L3**, type **= E7**, and press **Enter**. In cell **L4**, we want to have the computed predicted y value from (2.4). So we type **=E7+E6*M4**, and press **Enter**. Note that instead of typing all those cell references, you can just move your cursor to the cells of interest as if you were actually getting the needed values—this is a very good way to avoid typing errors. So, you would type the equal sign, move your cursor to **E7** and left-click to select it, type the plus sign, move your cursor to cell **E6** and left-click to select it, type the asterisk, move your cursor to sell **M4** and left-click to select it, and finally press **Enter**. Once you have done all of that, your worksheet should look like this:

	L	M	N
1	Points to graph regression line		
2	**y**	**x**	
3	83.41601	0	
4	440.7535	35	

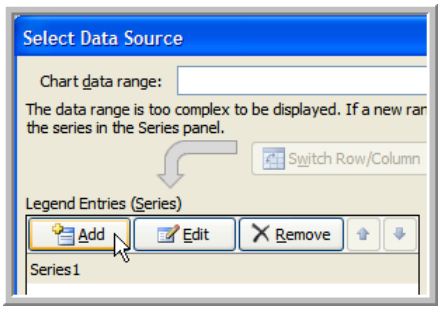
Note that the predicted y value we obtain in the worksheet for $x = 35$ is slightly different than the one we just computed in equation (2.4) due to rounding number differences.

Now, go back to your **Figure 2.6** worksheet. The data we have plotted on the chart represent *one* set or series of data. The two new pairs of values we want to add to this chart represent a *second* set or series of data.

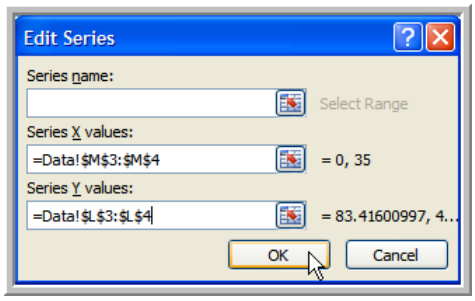
Select the **Design** tab, then the **Select data** button from the **Data** group of commands.



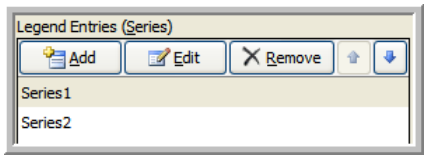
In the **Legend Entries (Series)** window of the **Select data source** dialog box, select the **Add** button.



Place your cursor in the **Series X values** window of the **Edit series** dialog box, and select **M3:M4** in the **Data worksheet**. Place your cursor in the **Series Y values** window (delete whatever is in there), and select **L3:L4** in the **Data worksheet**. Select **OK**.

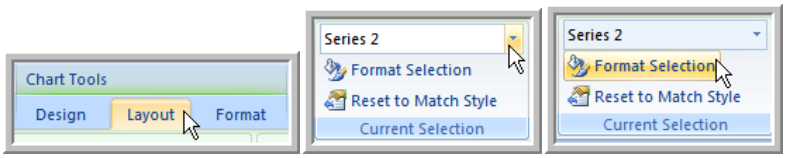


The **Select data source** dialog box reappears. A second data series, **Series2**, was created from the selection you just specified. Select **OK**.



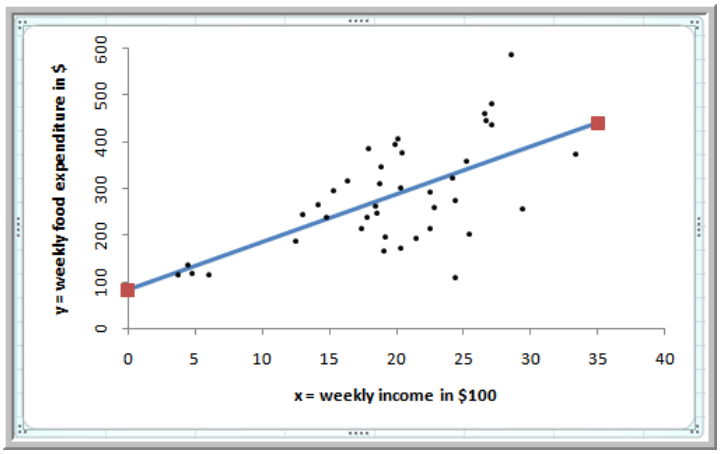
The two points from your new series are plotted on your chart (squares below):

Now, we need to draw a line across those two points. Go to the **Layout** tab. Change the **Current selection** (group of command to the far left) to **Series 2** (use the arrow down button to the right of the window to make that selection). Select **Format selection**.



A **Format data series** dialog box pops up. Select **Line color** and change its selection from **No line** to **Solid line**. Select **Close**.

The result is:

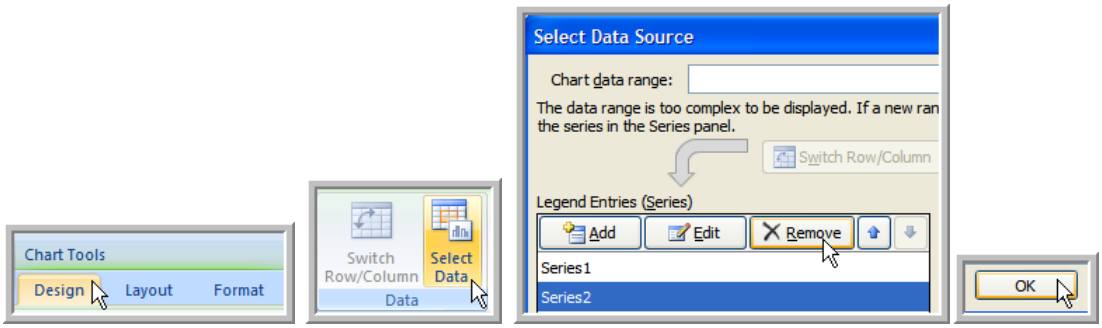


Note that while you *need* only two points to be able to draw a straight line, you *can use* more than two points. So we could have computed a predicted level of food expenditure for every level of income we have in our original data set, and use the 40 $(x_i, \hat{y}_i)$ pairs of values as our data Series 2. This is actually what Excel does when it adds a **Linear Trend Line** to a **Scatter** chart or a **Line** of best **Fit** to **Plots** of data as part of the **Regression Analysis** routine.

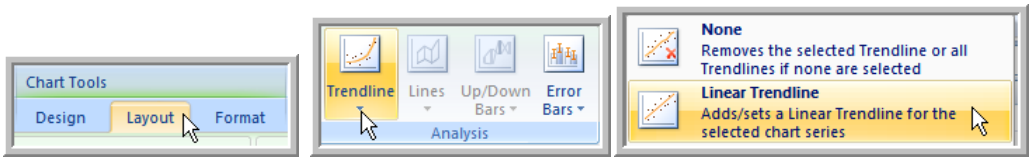
We are going to delete the line and two points we just added to our graph and successively look at these other two ways to plot our regression line.

2.3.2 Using Excel Built-in Feature

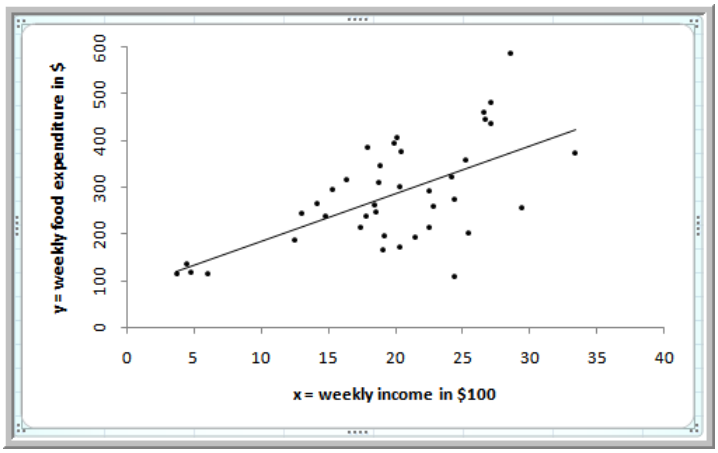
In the **Design** tab, go back to the **Data** group of commands, and select the **Select Data** button. In the **Select Data Source** dialog box, select **Series2** and **Remove**. Finally select **OK**.



To add a **Linear Trend Line**, select the **Layout** tab. Go to the **Analysis** group of commands, select **Trendline**, and then **Linear Trendline**.



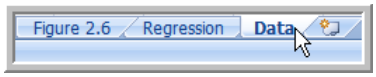
Your chart should look like this (see also Figure 2.8 p. 54 in *Principles of Econometrics, 4e*):



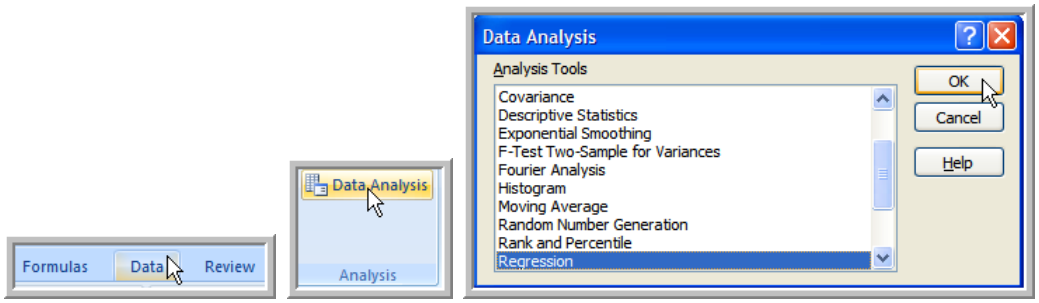
2.3.3 Using a Regression Option

You can also have Excel add the **Line** that best **Fit** your data by choosing that option on the **Regression** dialog box.

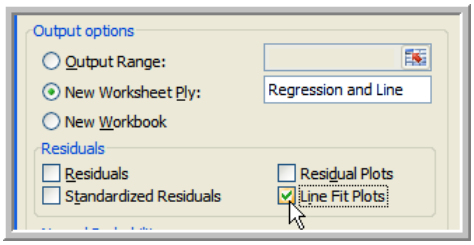
Go back to your **Data** worksheet (bottom left corner of your screen).



Select the **Data** tab, located in the middle of your tab list. Select **Data Analysis** on the **Analysis** group of commands to the far right of the ribbon. Select **Regression** in the **Data Analysis** dialog box, and then **OK**.

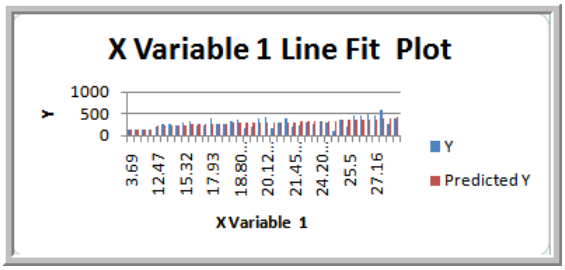


In the **Regression** dialog box, proceed as you did before, except this time, name your worksheet **Regression and Line**, and check the box in front of **Line Fit Plots**. Select **OK**.



In addition to the **Summary Output** you now have a **Residual Output** table and a **Chart** in your new worksheet. The **Residual Output** table is only partially shown below, and shown after **AutoFit**ting the **Column Width** (see Section 2.2.2 for more details on that).

	A	B	C
22	RESIDUAL OUTPUT		
23			
24	*Observation*	*Predicted Y*	*Residuals*
25	1	121.0895908	-5.869589792
26	2	128.2363405	7.743655458
27	3	131.9118118	-12.57181584
28	4	144.9801542	-30.02015524
29	5	210.7302519	-23.68024894



The **Predicted Y** or $\hat{y}_i$ values have been computed for all the original observed x_i values, similarly to the way we computed $\hat{y}$ for $x = 35$ (see Section 2.3.1).

The least squares **Residuals** are defined as

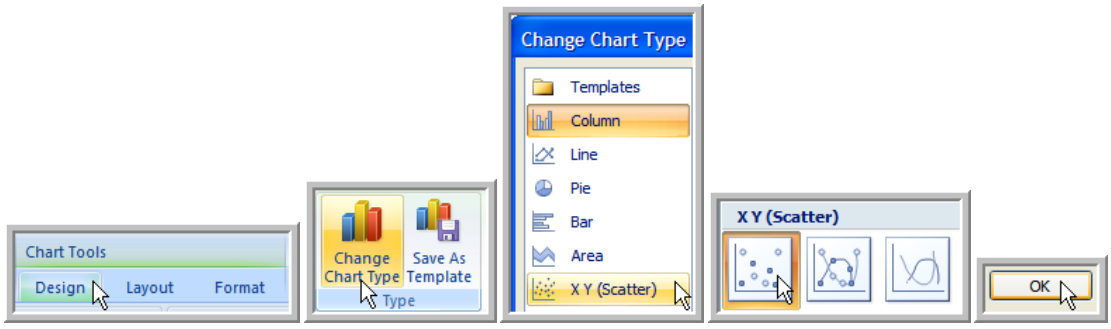
$$\hat{e}_i = y_i - \hat{y}_i = y_i - b_1 - b_2 x_i \tag{2.5}$$

You can compare the **Predicted Y** and **Residuals** values reported in the Excel **Residual Output** to the ones reported in Table 2.3 of *Principles of Econometrics, 4e* (p. 66). They should be the same.

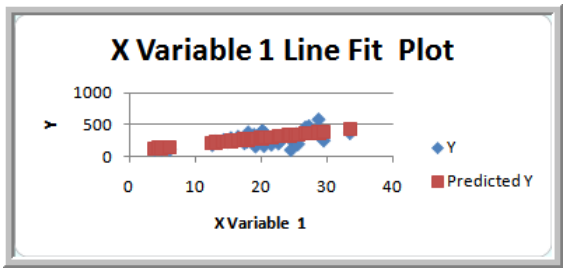
2.3.4 Editing the Chart

Now, the chart needs a little bit of editing. For one it looks like it is a **Column chart** as opposed to a **Scatter** one. The scales could be changed. Finally, **Chart** and **Axis titles** are not currently very helpful.

Place your cursor anywhere in the **Chart area**, and left-click, so that **Chart Tools** are made available to you again. Select the **Design** tab. Go to the far left group of commands, **Type**, and select **Change Chart Type**. In the **Change Chart Type** dialog box, select **X Y (Scatter)** chart, and then **Scatters with only Markers**. Finally, select **OK**.

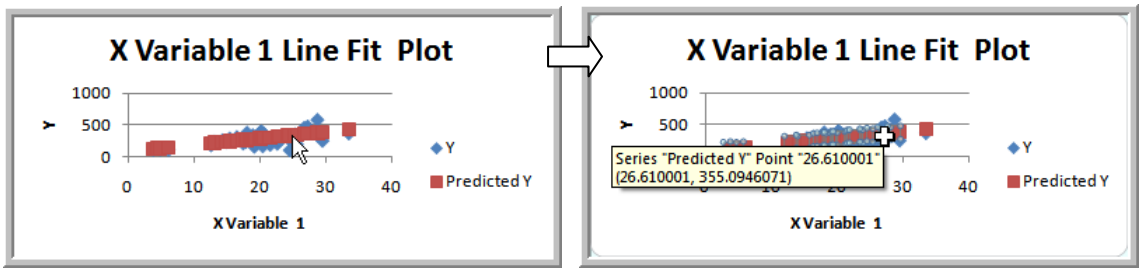


The result is:

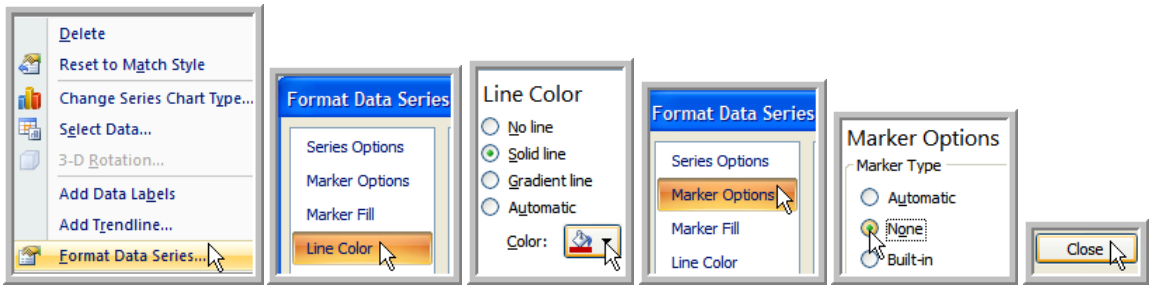


Now that we have the correct chart type, we would like to draw a line through all the **Predicted Y** points. Actually, since we are using those points to draw our regression line, what we want to show is only the line. So, we will use the points to draw the line, and then get rid of those big square points. This way our chart won't be as busy.

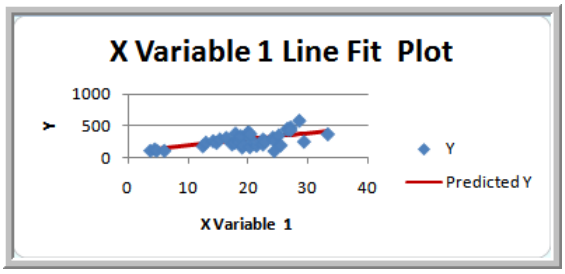
On your chart, select the **Predicted Y** points with your cursor. Your cursor should turn into a fat cross as shown below:



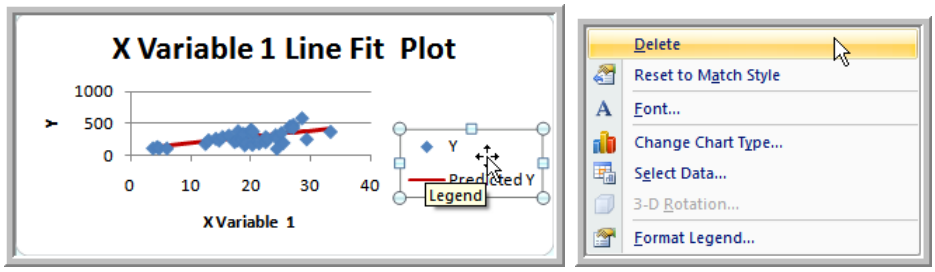
Right-click and select **Format Data Series**. A **Format Data Series** dialog box pops up. Select **Line Color** and **Solid line**. Change the line color to something different from the **Y** points. Select **Marker Options**, and change the **Marker Type** from **Automatic** to **None**. Select **Close**.



The result is:

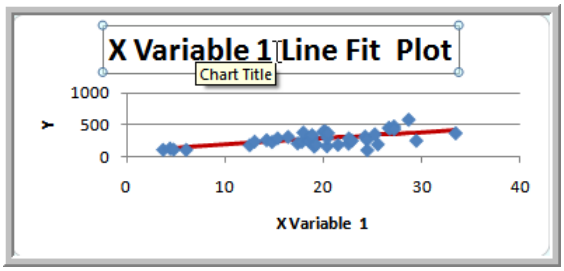


On your chart, select the **Legend** with your cursor, right-click and select **Delete**.

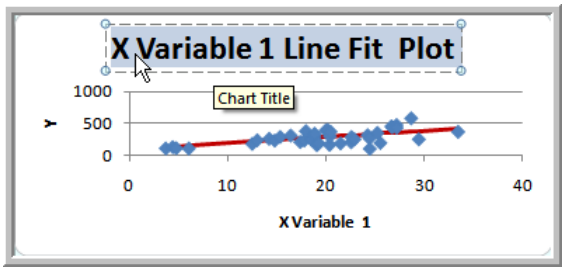


Change the **Chart** and **Axis titles** as you see fit. Below, we show you how you can change the **Chart title**. You can follow a similar process to change the **Axis titles**.

Place your cursor in the title area and left click.

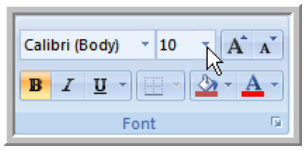


Select the generic title.

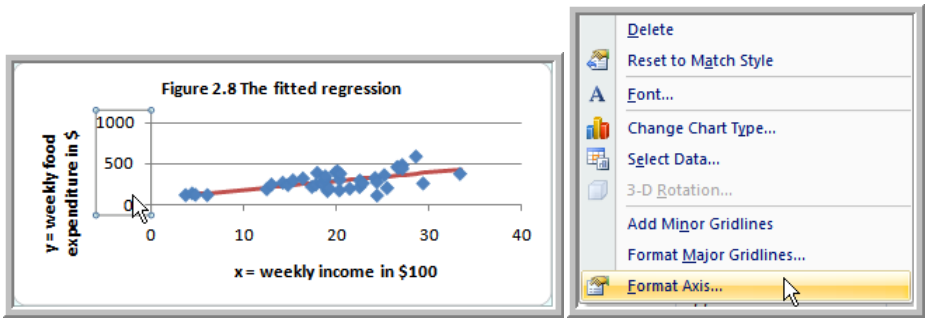


Type in your new title.

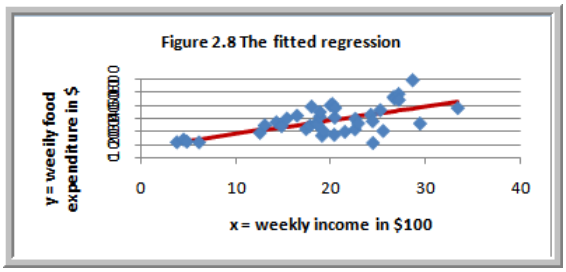
You can select any of the titles and change the **Font** size by going back to the **Home** tab. Select what you need on the **Font** group of commands.



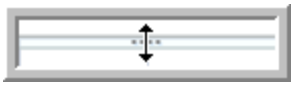
You can reformat the *y*-axis (and/or the *x*-axis) by selecting it with your cursor, right-clicking and selecting **Format Axis**.



If you proceed as you did before to edit your vertical axis (see Section 2.1.2a), you should obtain the following:

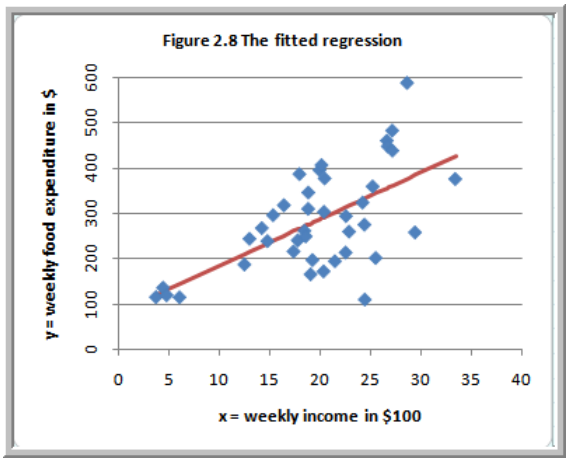


To resize the whole **Chart area**, put your cursor over its lower border until it turns into a double cross arrow as shown below.

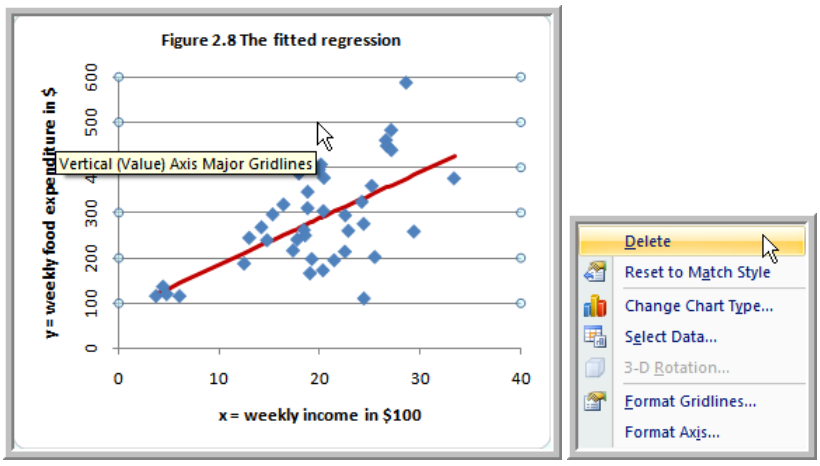


Left click, and it should turn into a skinny cross.

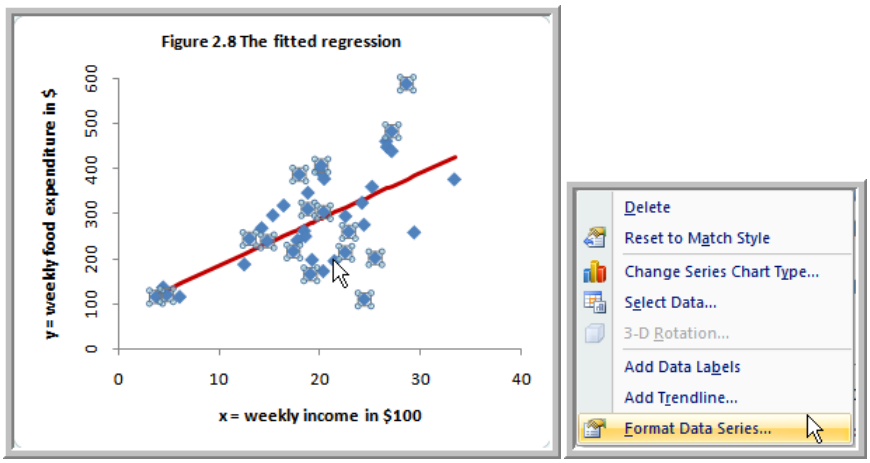
Hold it, and drag it down until you are satisfied with the way your chart looks.



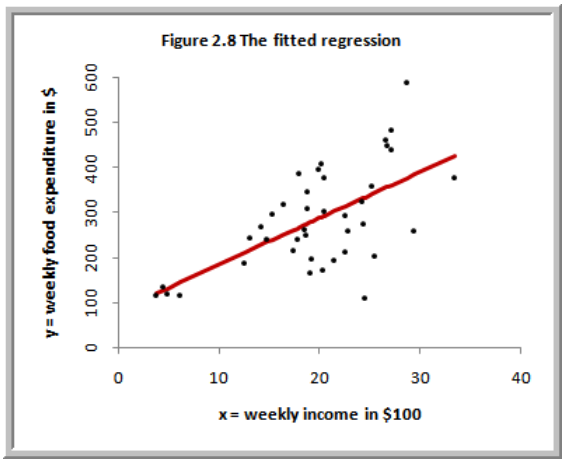
You can delete the **Gridlines** by first selecting them, right-clicking and then selecting **Delete**.



You can also reformat the **Data Series Y** by selecting the points, right-clicking and selecting **Format Data Series**. Then proceed as you did before to change your markers' options (see Section 2.1.2c).



Your result might be (see also Figure 2.8 p. 54 in *Principles of Econometrics, 4e*):



In this next section we illustrate the concept of unbiased estimators.

2.4 EXPECTED VALUES OF b_1 AND b_2

To show that under the assumptions of the simple linear regression model, $E(b_1) = \beta_1$ and $E(b_2) = \beta_2$, we first put ourselves in a situation where we know our population and regression parameters (i.e. we know the truth). We then use the least squares regression technique to unveil the truth (which we already know). This allows us to check on the validity of the least squares regression technique, and specifically to check on the unbiasedness of the least squares estimators.

2.4.1 Model Assumptions

First, let us restate the assumptions of the simple linear regression model (see p. 45 of *Principles of Econometrics, 4e*):

- The mean value of y, for each value of x, is given by the linear regression function:

$$E(y|x) = \beta_1 + \beta_2 x \tag{2.6}$$

- For each value of x, the values of y are distributed about their mean value, following probability distributions that all have the same variance:

$$var(y|x) = \sigma^2 \tag{2.7}$$

- The sample values of y are all uncorrelated and have zero covariance, implying that there is no linear association among them:

$$cov(y_i, y_j) = 0 \tag{2.8}$$

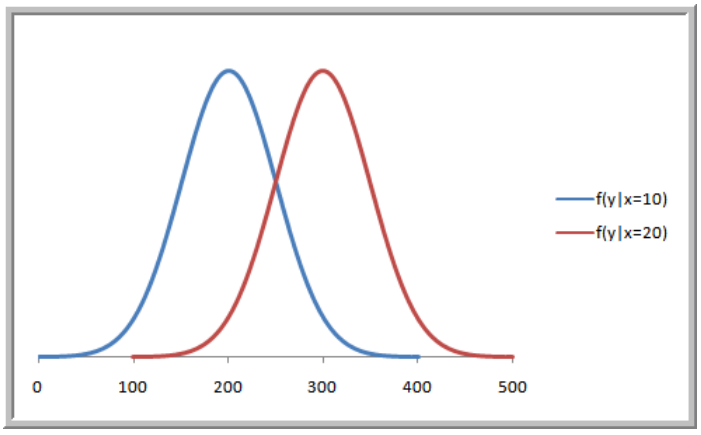
- The variable x is not random and must take at least two different values.

- (*optional*) The values of y are normally distributed about their mean for each value of x:

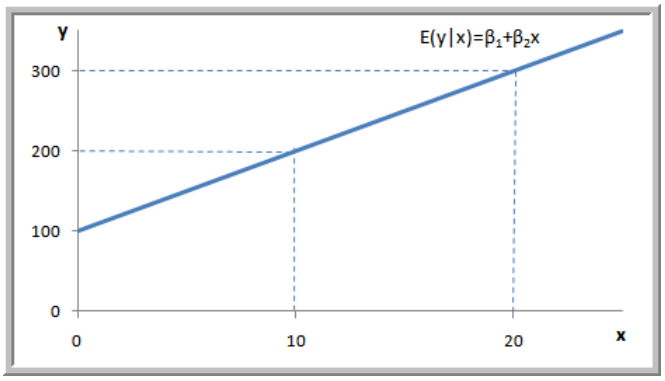
$$y \sim N[(\beta_1 + \beta_2 x), \sigma^2] \tag{2.9}$$

In the specific and simplified case we are considering in this section, half of our hypothetical population of three person households has a weekly income of \$1000 ($x = 10$), and half of it has a weekly income of \$2000 ($x = 20$). Because we are all mighty, we know the values of our population parameters, and consequently the values of our regression parameters. Let $\mu_{y|x=10} = 200$, $\mu_{y|x=20} = 300$, and $var(y|x = 10) = var(y|x = 20) = \sigma^2 = 2500$. This implies $\beta_1 = 100$ and $\beta_2 = 10$.

The probability distribution functions of weekly food expenditure, y, given an income level $x = 10$ and an income level $x = 20$, are assumed to be Normal. They look like this:



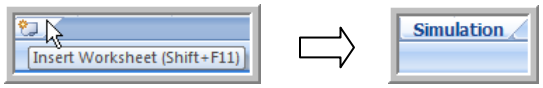
The linear relationship between weekly food expenditure and weekly income looks like the following:



Let us emphasize the difference between this section and Chapter 2 in *Principles of Econometrics, 4e*. In this section, we do *know* the truth. In other words, we have information regarding weekly food expenditure and weekly food income on *all* three person households that constitute our population. In Chapter 2 of *Principles of Econometrics, 4e*, like it is the case in real-life, you do not have that population information. You must thus rely *solely* on your random sample information to make inferences about your population.

Now, as an exercise, and as a way to prove the unbiasedness of the least squares estimators, we are going to use the least square regression technique to unveil the truth.

Insert a new worksheet in your workbook by selecting the **Insert Worksheet** tab at the bottom of your screen (or Press the **Shift** *and* **F11** keys). Name it **Simulation**.



We are going to draw a random sample of 40 households from our population. Half of the sample is drawn from the first type of households, with weekly income $x = 10$; and half of the sample is drawn from the second type of households, with weekly income $x = 20$.

Let us keep records of the level of weekly income for our 40 households in column **A** of our **Simulation** worksheet: in cell **A1**, type **x** and **Right-Align** it; in cells **A2:A21**, record the value **10**; in cells **A22:A41**, record the value **20**.

	A
1	x
2	10
3	10
4	10
5	10
6	10
7	10
8	10
9	10
10	10
11	10
12	10
13	10
14	10
15	10
16	10
17	10
18	10
19	10
20	10
21	10

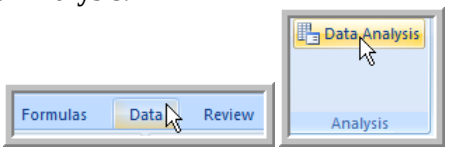
	A
22	20
23	20
24	20
25	20
26	20
27	20
28	20
29	20
30	20
31	20
32	20
33	20
34	20
35	20
36	20
37	20
38	20
39	20
40	20
41	20
42	

2.4.2 Random Number Generation

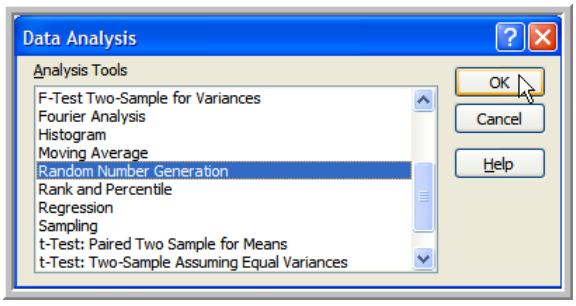
We use the **Random Number Generation** analysis tool to draw our random sample of households. We keep record of their weekly food expenditure in column **B** of our **Simulation** worksheet: type **y** in **B1**, and **Right-Align** it.

	A	B
1	x	y

Select the **Data** tab, in the middle of your tab list. On the **Analysis** group of commands to the far right of the ribbon, select **Data Analysis**.

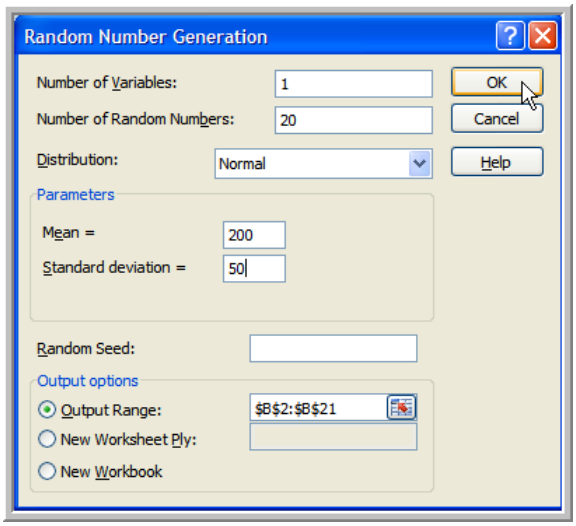


The **Data Analysis** dialog box pops up. In it, select **Random Number Generation** (you might need to use the scroll up and down bar to the right of the **Analysis Tools** window to find it), then select **OK**.



A **Random Number Generation** dialog box pops up. Since we are drawing *one* random sample, we specify **1** in the **Number of Variables** window. We first draw a random samples of 20 from

households with weekly income of $x = 10$, so we specify the **Number of Random Numbers** to be **20**. For simplicity we assumed that our population of households has weekly food expenditure that is normally distributed, so this is the distribution we choose. Once you have selected **Normal** in the **Distribution** window, you will be able to specify its **Parameters**: for $x = 10$, its **Mean** is $\mu_{y|x=10} = \mathbf{200}$ and its **Standard deviation** is $\sqrt{var(y|x = 10)} = \sigma = \mathbf{50}$. Select the **Output Range** in the **Output options** section, and specify it to be **B2:B21** in your **Simulation** worksheet. Finally, select **OK**.



Repeat to draw a random sample of 20 from households with weekly income of $x = 20$. Change the **Mean** to $\mu_{y|x=10} = \mathbf{300}$ and the **Output Range** to **B22:B41**.

Here is the random sample that we obtained. NOTE: you will obtain a *different* random sample, due to the nature of random sampling.

	A	B
1	x	y
2	10	122.4908
3	10	163.1711
4	10	221.0102
5	10	294.1295
6	10	192.9407
7	10	228.5627
8	10	223.1013
9	10	184.7241
10	10	164.8267
11	10	125.1754
12	10	274.037
13	10	136.9209
14	10	190.4468
15	10	121.6272
16	10	202.8224
17	10	123.431
18	10	116.1414
19	10	209.413
20	10	152.0113
21	10	200.4915

	A	B
22	20	274.6751
23	20	336.5785
24	20	303.5467
25	20	216.4365
26	20	358.9562
27	20	278.1513
28	20	267.9295
29	20	331.2386
30	20	328.9643
31	20	297.1585
32	20	338.727
33	20	297.3423
34	20	201.3894
35	20	309.4636
36	20	305.0402
37	20	334.5588
38	20	286.2402
39	20	273.6785
40	20	318.1071
41	20	283.9447
42		

2.4.3 The LINEST Function

Next, we use the **LINEST** function to obtain the least squares estimates for the intercept and slope parameters, based on the random sample we just drew. The **LINEST** function is an alternative to using the Least Squares Estimators' Formulas (see Section 2.2.1) or the Excel Regression Analysis Routine (see Section 2.2.2). It allows us to quickly get the least squares estimates for the intercept and slope parameters. For this purpose, the general syntax of the **LINEST** function is as follows:

= LINEST(*y*'s, *x*'s)

The first argument of the **LINEST** function specifies the y values, and the second argument specifies the x values, the least squares estimates are based on. In our case, we thus need to specify:

= LINEST(B2:B41,A2:A41)

The **LINEST** function creates a table where it stores the least squares estimates in Excel memory. It first reports the slope coefficient estimate, and then the intercept coefficient estimate. So, if we were to look into Excel memory, the estimates would be reported as shown below:

	column 1	**column 2**
row 1	$\mathbf{b_2}$	$\mathbf{b_1}$

We nest the **LINEST** function in the **INDEX** function to get the estimated coefficients, *one at a time*. The **INDEX** function returns values from within a table. In the case of a table with only one row, the **INDEX** function general syntax is as follows:

= INDEX(table of results, column_num)

The first argument of the **INDEX** function specifies which table to get the results from. In our case, this is the table of results generated by the **LINEST** function above. So, we replace "table of results" by "**LINEST(B2:B41,A2:A41)**". The second argument indicates from which column of the table to retrieve the result of interest to us. So, if we want to retrieve the estimate of the intercept coefficient, b_1**,** from the table above, we would indicate that it can be found in column 2 by replacing "column_num" by "**2"**.

We are going to report our estimated coefficients at the bottom of our table. In cell **A43**, type **b1** =; in cell **A44**, type **b2** =. **Bold** those labels. In cell **B43** and **B44**, type the following equations, respectively:

	A	B
43	**b1=**	**=INDEX(LINEST(B2:B41,A2:A41),2)**
44	**b2=**	**=INDEX(LINEST(B2:B41,A2:A41),1)**

Here are the estimates that we get:

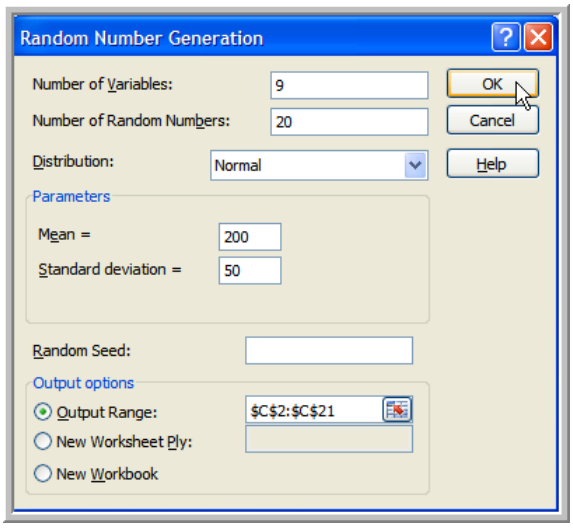
	A	B
43	**b1** =	67.64114
44	**b2** =	11.47326

The estimates of the intercept and slope coefficients are based on *one* random sample. Our random sample is different than yours, and each random sample yields different estimates, which may or may not be close to the true parameter values. The property of unbiasedness is about the *average* values of b_1 and b_2 if *many* samples of the same size are drawn from the same population. In the next section, we are thus going to repeat our sampling and least squares estimation exercise.

2.4.4 Repeated Sampling

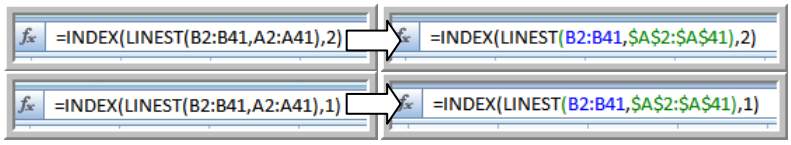
Note that in Chapter 2 of *Principles of Econometrics, 4e*, the repeated samples given to you were randomly collected from a population with *unknown* parameters. In this section, we draw our samples from a population with *known* parameters.

Go back to the **Random Number Generation** dialog box. We would like to draw 9 additional random samples, so we specify **9** in the **Number of Variables** window. Again, we first draw random samples of 20 from households with weekly income of $x = 10$, so we specify the **Number of Random Numbers** to be **20**. We also select **Normal** in the **Distribution** window, and specify its **Parameters**. For $x = 10$, its **Mean** is $\mu_{y|x=10} = \mathbf{200}$ and its **Standard Deviation** is $\sqrt{var(y|x = 10)} = \sigma = \mathbf{50}$. Specify the **Output Range** to be **C2:K21**. Finally, select **OK**.



Repeat to draw a random sample of 20 from households with weekly income of $x = 20$. Change the **Mean** to $\mu_{y|x=10} = \mathbf{300}$ and the **Output Range** to **C22:K41**.

Next, before we copy the formula to get our coefficient estimates, we need to transform their **Relative cell references A2:A41** into **Absolute cell references $A$2:$A$41**, since we will be using the same *x*-values for our next 9 rounds of least squares estimates.



Copy the formulas from **B43:B44** into **C43:K44**. In cells **L43:L44** compute the **AVERAGE**s of your estimates from your 10 samples. In cell **L43**, you should have **=AVERAGE(B43:K43)**; in cell **L44**, you should have **=AVERAGE(B44:K44)**. The estimates and average values that we get for our 10 samples are:

	A	B	C	D	E	F	G	H	I	J	K	L
43	**b1 =**	67.64114	66.92893	110.0845	60.41892	102.9383	127.2066	68.02508	80.43498	132.2953	75.4688	**89.14425**
44	**b2 =**	11.47326	12.2687	8.813088	11.73885	10.11186	8.6169	11.5521	10.8758	8.048971	11.33003	**10.48296**

If we took the averages of estimates from many samples, these averages would approach the true parameter values β_1 and β_2. To show you that this is the case, we repeated the exercise again. Here are the average values of b_1 and b_2 that we did get as we increased the number of samples from 10, to 100, and finally to 1000:

Number of samples	**10**	**100**	**1000**	**Parameter Values**
Average value of b_1	89.14425	98.44593	99.48067	**100**
Average value of b_2	10.48296	10.08958	10.04135	**10**

The next section of this chapter is very short. It points out how you can compute an estimate of the variances and covariance of the least squares estimators b_1 and b_2 using Excel. It also outlines other numbers you can recognize in the Excel summary output. Note that for this section we are getting back to our food expenditure and income data of Sections 2.1-2.3, i.e. data from *one* sample of 40 households that was drawn from a population with *unknown* parameters.

2.5 VARIANCES AND COVARIANCE OF b_1 AND b_2

You can compute an estimate of the variances and covariance of the least squares estimators b_1 and b_2, the same way you computed b_1 and b_2. Consider their algebraic expressions (see below or p. 65 of *Principles of Econometrics*, *4e*), and perform the simple arithmetic operations needed. You might want to do that as an exercise; you will be able to check on your work by comparing your estimates to the one reported on pp. 66-67 of *Principles of Econometrics*, *4e*.

Estimates of the variances and covariance of the least squares estimators b_1 and b_2 are given by:

$$\widehat{var(b_1)} = \hat{\sigma}^2 \left[\frac{\sum x_i^2}{N \sum (x_i - \bar{x})^2} \right] \tag{2.10}$$

$$\widehat{var(b_2)} = \frac{\hat{\sigma}^2}{\sum (x_i - \bar{x})^2} \tag{2.11}$$

$$\widehat{cov(b_1, b_2)} = \hat{\sigma}^2 \left[\frac{-\bar{x}}{\sum (x_i - \bar{x})^2} \right] \tag{2.12}$$

where: N is the total number of pairs of values,

and $\hat{\sigma}^2 = \frac{\sum \hat{e}_i^2}{N-K}$ is an estimate of the error variance, (2.13)

where: K is the number of regression parameters, $K = 2$,

and $\hat{e}_i = y_i - \hat{y}_i = y_i - b_1 - b_2 x_i$ are the least squares residuals.

The square roots of the estimated variances are the standard errors of b_1 and b_2. They are denoted as $se(b_1)$ and $se(b_2)$.

$$se(b_1) = \sqrt{\widehat{var(b_1)}} \quad \text{and} \quad se(b_2) = \sqrt{\widehat{var(b_2)}} \tag{2.14}$$

Excel regression routine does not automatically generate estimates of the variances and covariance of the least squares estimators b_1 and b_2, but it does compute the standard errors of b_1 and b_2, as well as other intermediary results.

Specifically, the following estimates can be found in the Excel **Summary Output** you generated earlier:

$\sum \hat{e}_i^2$:	Sum of Squared Residuals (**SS Residual)**	in **C13**
$\hat{\sigma}^2$:	Mean Square Residual (**MS Residual)**	in **D13**
$\hat{\sigma}$:	**Standard Error** of the **Regression**	in **B7**
$se(b_1)$ and $se(b_2)$:	**Standard Errors** of **Intercept** and **X Variable 1**	in **C17:C18**

	A	B	C	D	E	F	G	H	I
1	SUMMARY OUTPUT								
2									
3	*Regression Statistics*								
4	Multiple R	0.620485472							
5	R Square	0.385002221							
6	Adjusted R Square	0.368818069							
7	Standard Error	89.51700429							
8	Observations	40							
9									
10	ANOVA								
11		*df*	*SS*	*MS*	*F*	*Significance F*			
12	Regression	1	190626.9788	190626.9788	23.78884107	1.94586E-05			
13	Residual	38	304505.1742	8013.294058					
14	Total	39	495132.153						
15									
16		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
17	Intercept	83.41600997	43.41016192	1.921577951	0.062182379	-4.463267721	171.2952877	-4.463267721	171.2952877
18	X Variable 1	10.2096425	2.093263461	4.877380554	1.94586E-05	5.972052202	14.4472328	5.972052202	14.4472328

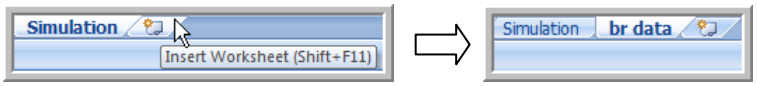
Note that $\sum \hat{e}_i^2$, the **Sum of Squared Residuals** (**SS Residual)**, is also referred to as the **Sum of Squared Errors**—hence the abbreviation **SSE** used in p. 51 of *Principles of Econometrics*, *4e*.

2.6 NONLINEAR RELATIONSHIPS

2.6.1 A Quadratic Model

2.6.1a Estimating the Model

Open the Excel file ***br***. Excel opens the data set in Sheet 1 of a new Excel file. Since we would like to save all our work from Chapter 2 in one file, create a new worksheet in your **POE Chapter 2** Excel file, name it **pr data**, and in it, copy the data set you just opened.



This data set contains data on 1080 houses sold in Baton Rouge, LA during mid-2005, which we are using to estimate the following quadratic model for house prices:

$$\boldsymbol{PRICE = \alpha_1 + \alpha_2 SQFT^2 + e} \tag{2.15}$$

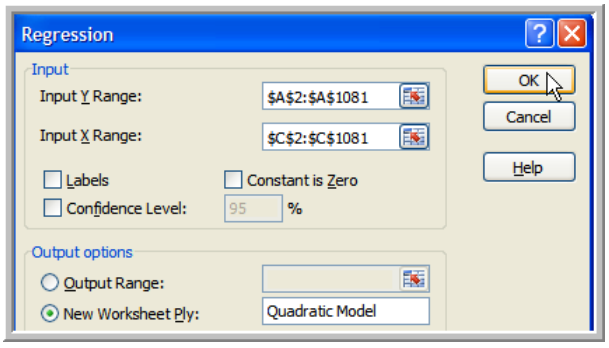
In your **br data** worksheet, insert a column to the right of the **sqft** column **B** (see Section 1.4 for more details on how to do that). In your new cells **C1:C2**, enter the following column label and formula.

	C
1	**sqft^2**
2	=B2^2

Copy the content of cells **C2** to cells **C3:C1081**. Here is how your table should look (only the first five values are shown below):

	A	B	C
1	**price**	**sqft**	**sqft^2**
2	66500	741	549081
3	66000	741	549081
4	68500	790	624100
5	102000	2783	7745089
6	54000	1165	1357225

In the **Regression** dialog box, the **Input Y Range** should be **A2:A1081**, and the **Input X Range** should be **C2:C1081**. Select **New Worksheet Ply** and name it **Quadratic Model**. Finally select **OK**.

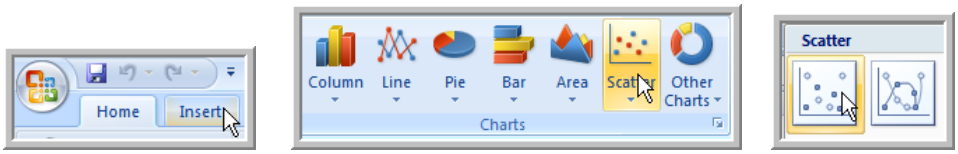


The result is (matching the one reported on p. 70 in *Principles of Econometrics, 4e*):

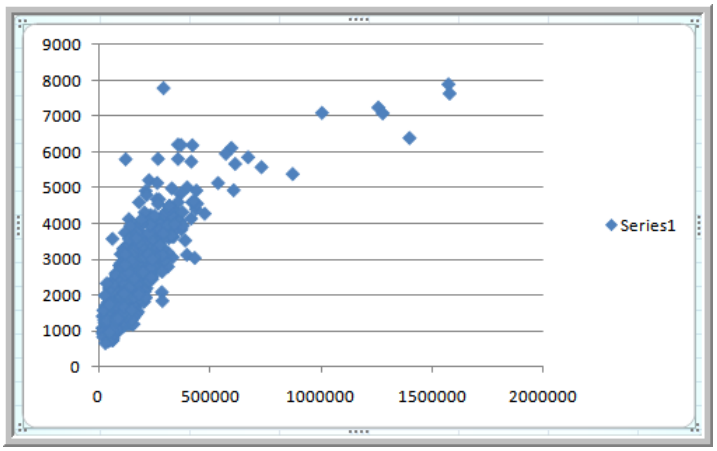
	A	B	C	D	E	F	G	H	I
1	SUMMARY OUTPUT								
2									
3	*Regression Statistics*								
4	Multiple R	0.832075415							
5	R Square	0.692349497							
6	Adjusted R Square	0.692064107							
7	Standard Error	68206.74032							
8	Observations	1080							
9									
10	ANOVA								
11		*df*	*SS*	*MS*	*F*	*Significance F*			
12	Regression	1	1.1286E+13	1.1286E+13	2425.976064	3.3748E-278			
13	Residual	1078	5.01503E+12	4652159426					
14	Total	1079	1.63011E+13						
15									
16		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
17	Intercept	55776.56564	2890.441213	19.29690367	1.67487E-71	50105.0373	61448.09398	50105.0373	61448.09398
18	X Variable 1	0.015421301	0.000313096	49.25419844	3.3748E-278	0.014806954	0.016035648	0.014806954	0.016035648

2.6.1b Scatter of Data and Fitted Quadratic Relationship

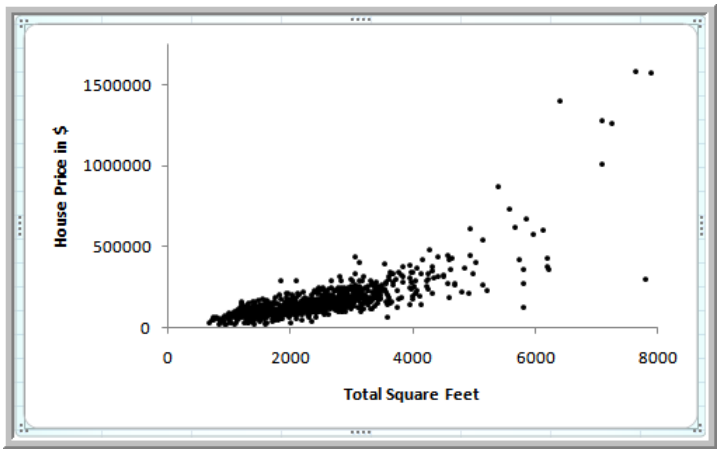
Go back to your **br data** worksheet and select **A2:B1081**. Select the **Insert** tab located next to the **Home** tab. In the **Charts** group of commands select **Scatter**, and then **Scatter with only Markers**.



The result is:



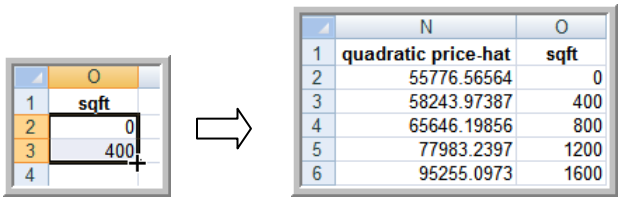
You can see that our house price values are on the horizontal axis and square footage values are on the vertical axis; we would like to change that around and edit our chart as we did in Section 2.1 with our plot of food expenditure data. The result is (see also Figure 2.14 on p. 70 in *Principles of Econometrics, 4e*):



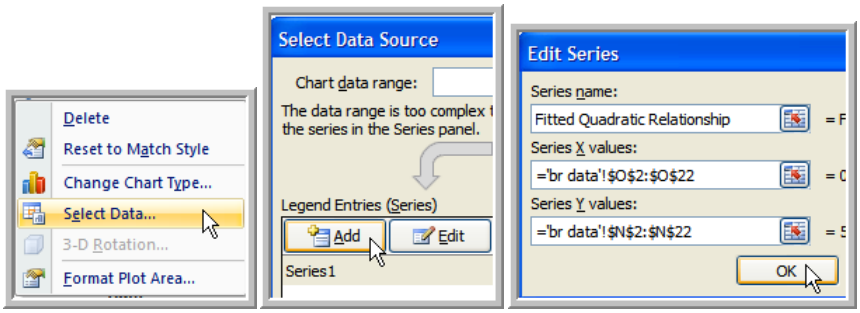
Finally, we add the fitted quadratic relationship to our scatter plot. In cells **N1:N2** and **O1:O3** of your **br data** worksheet , enter the following column label and formula.

	N	O
1	**quadratic price-hat**	**sqft**
2	='Quadratic Model'!$B$17+'Quadratic Model'!$B$18*'br data'!O2	0
3		400

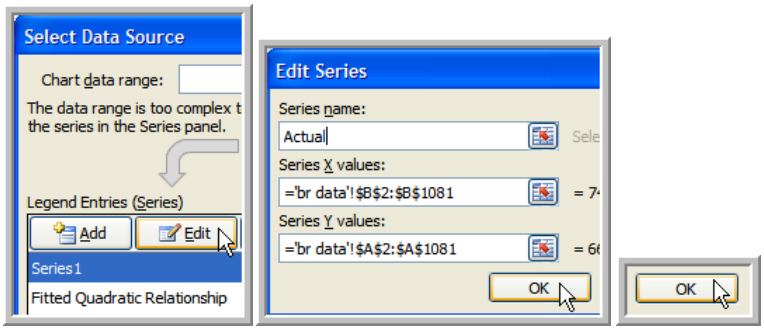
Select cells **O2:O3**, move your cursor to the lower right corner of your selection until it turns into a skinny cross as shown below; left-click, hold it and drag it down to cell **O22**: Excel recognizes the series and automatically completes it for you. Next, copy the content of cell **N2** to cells **N3:N22**. Here is how your table should look (only the first five values are shown below):



Go back to your scatter plot and right-click in the middle of your chart area. Select **Select Data**. In the **Legend Entries (Series)** window of the **Select Data Source** dialog box, select the **Add** button. In the **Series name** window, type **Fitted Quadratic Relationship**. Select **O2:O22** for the **Series X values** and select **N2:N22** for the **Series Y values**. Finally, select **OK**. The **Fitted Quadratic Relationship** series has been added to your graph.

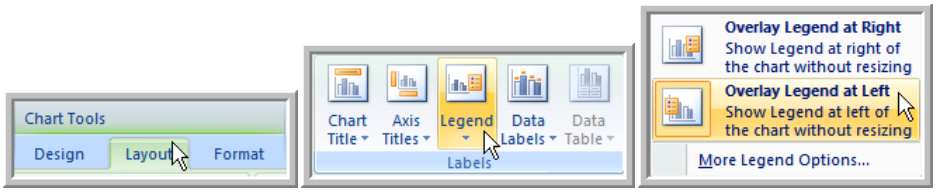


Before you close the **Select Data Source** dialog box, select **Series1** and **Edit**. Type the name **Actual** in the **Series name** window. Select **OK**. In the **Select Data Source** window that re-appears, select **OK** again.

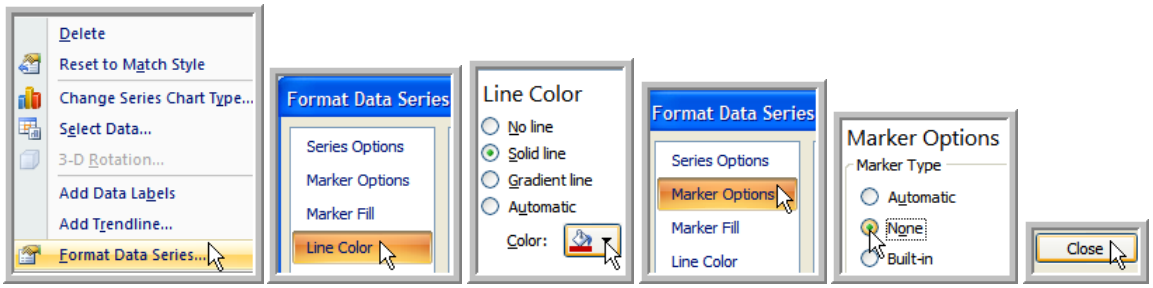


Make sure you chart is selected so that the **Chart Tools** are visible. In the **Layout** tab, go to the **Labels** group of commands. Select the **Legend** button and choose either one of the **Overlay**

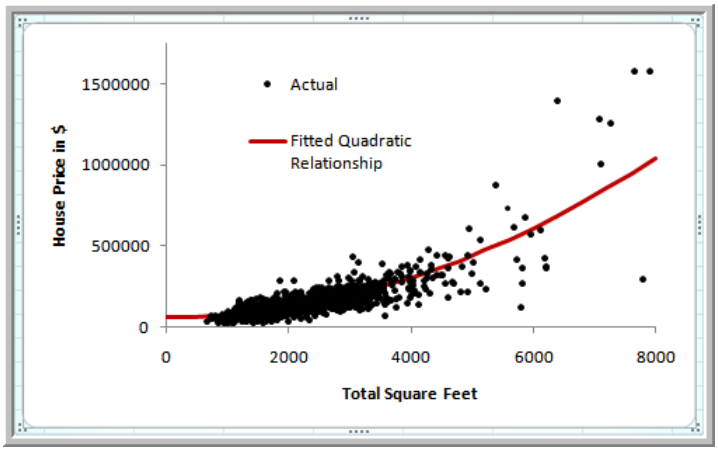
Legend options. Grab your legend with your cursor and move it to the upper left corner of your chart area.



Finally, we want to reformat our **Fitted Quadratic Relationship** values series. Select the plotted series in your chart area, right-click and select **Format Data Series**. A **Format Data Series** dialog box pops up. Select **Line Color** and **Solid line**. Change the line color to something different from the **Actual** series points. Select **Marker Options**, and change the **Marker Type** from **Automatic** to **None**. Select **Close**.



The result is (see also Figure 2.14 on p. 70 in *Principles of Econometrics, 4e*):



2.6.2 A Log-Linear Model

2.6.2a Histograms of PRICE and ln(PRICE)

In your **br data** worksheet, insert a column to the right of the **sqft**^{2} column **C** (see Section 1.4 for more details on how to do that). In your new cells **D1:D2**, enter the following column label and formula.

	D
1	**ln(price)**
2	=ln(A2)

Copy the content of cells **D2** to cells **D3:D1081**. Here is how your table should look (only the first five values are shown below):

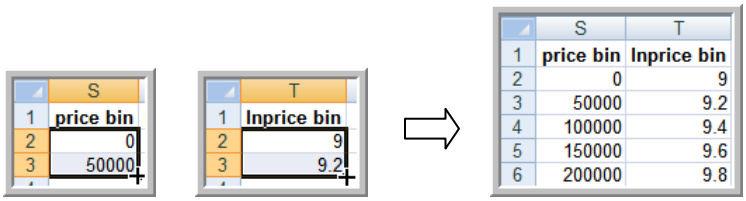
	A	B	C	D
1	**price**	**sqft**	**sqft²**	**ln(price)**
2	66500	741	549081	11.10496
3	66000	741	549081	11.09741
4	68500	790	624100	11.13459
5	102000	2783	7745089	11.53273
6	54000	1165	1357225	10.89674

Next, we specify **BIN** values. These values will determine the range of $\boldsymbol{PRICE}$ and $\boldsymbol{ln(PRICE)}$ values for each column of the histogram. The bin values have to be given in ascending order. Starting with the lowest bin value, a $\boldsymbol{PRICE}$ or $\boldsymbol{ln(PRICE)}$ value will be counted in a particular bin if it is equal to or less than the bin value.

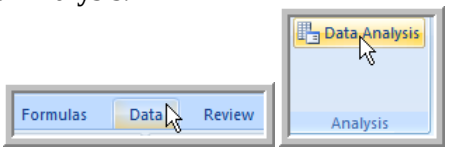
In cells **S1:T3** of your **br data** worksheet , enter the following column labels and data.

	S	T
1	**price bin**	**lnprice bin**
2	0	9
3	50000	9.2

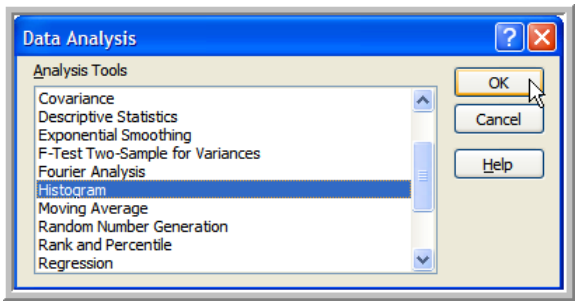
Select cells **S2:S3**, move your cursor to the lower right corner of your selection until it turns into a skinny cross as shown below; left-click, hold it and drag it down to cell **S34**: Excel recognizes the series and automatically completes it for you. Similarly, select cells **T2:T3**, move your cursor to the lower right corner of your selection until it turns into a skinny cross; left-click, hold it and drag it down to cell **T29**. Here is how your table should look (only the first five values are shown below):



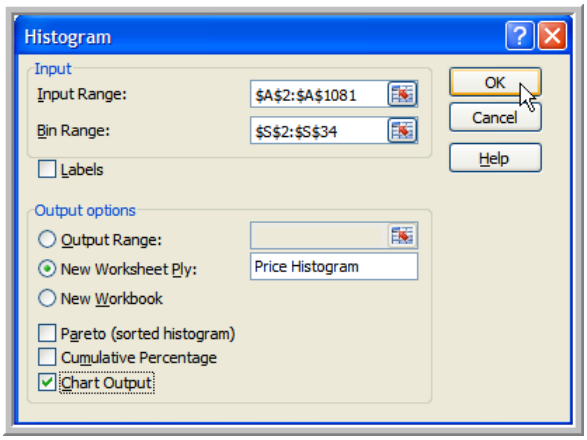
Select the **Data** tab, in the middle of your tab list. On the **Analysis** group of commands to the far right of the ribbon, select **Data Analysis**.



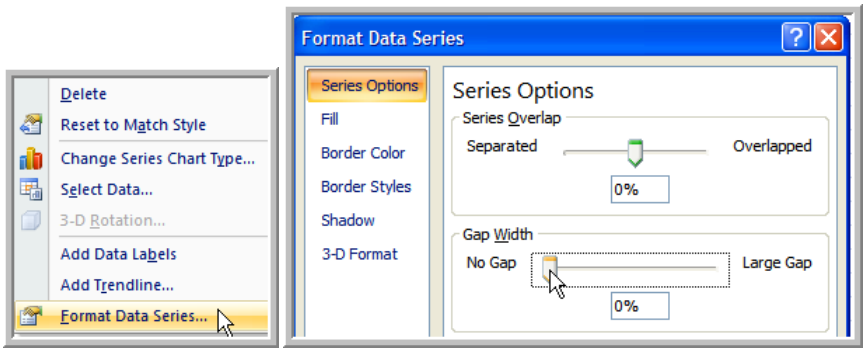
The **Data Analysis** dialog box pops up. In it, select **Histogram** (you might need to use the scroll up and down bar to the right of the **Analysis Tools** window to find it), then select **OK**.



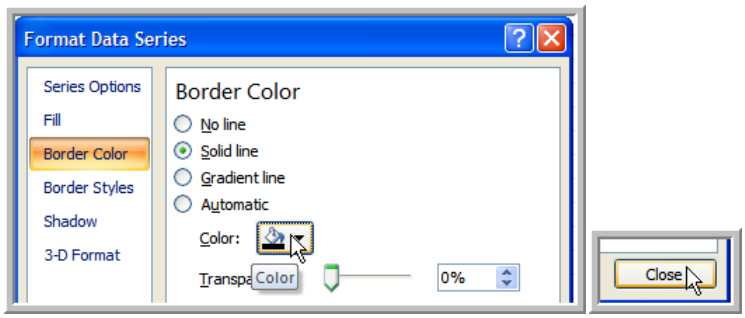
An **Histogram** dialog box pops up. For the **Input Range**, specify **A2:A1081**; for the **Bin Range**, specify **S2:S34**. The **Input Range** indicates the data set Excel will look at to determine how many values are counted in each bin of the **Bin Range**. Check the **New Worksheet Ply** option and name it **Price Histogram**; check the box next to **Chart Output**. Finally, select **OK**.



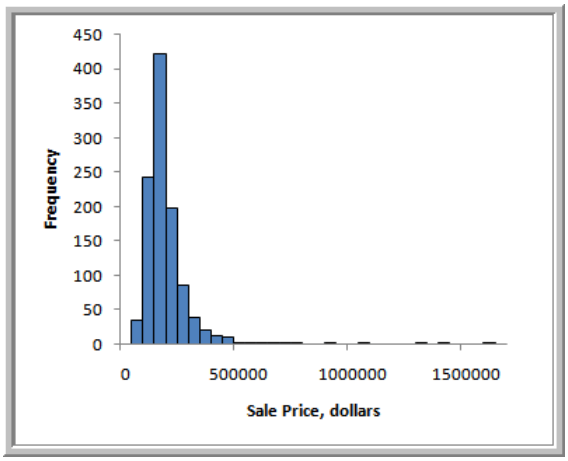
Select the columns in your chart area, right-click and select **Format Data Series**. The **Series Options** tab of the **Format Data Series** dialog box should be open. Select the **Gap Width** button and move it to the far left, towards **No Gap**.



Go to the **Border Color** tab and select **Solid line**, choose a different **Color** if you would like. Select **Close**.

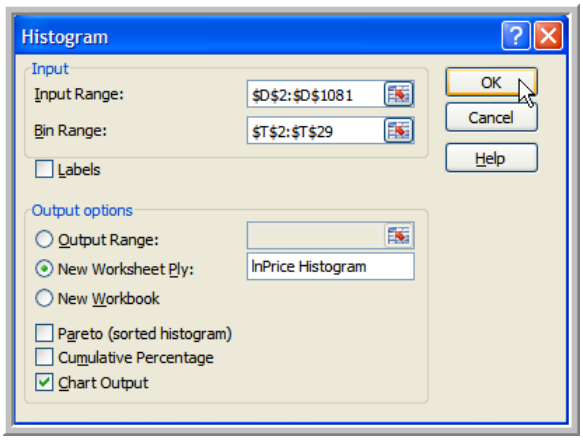


After editing our chart as we did in Section 2.1 with our plot of food expenditure data, the result is (see also Figure 2.16(a) on p. 72 in *Principles of Econometrics, 4e*):

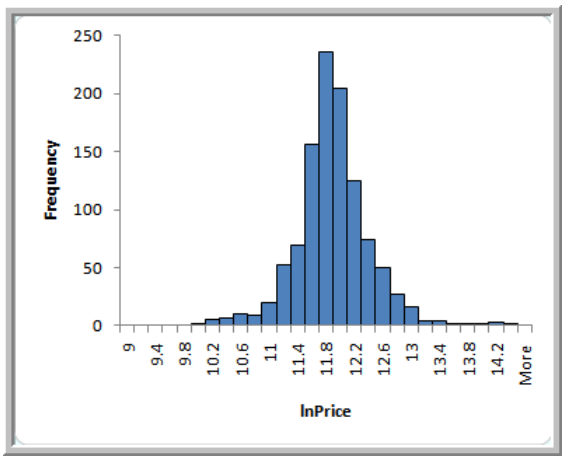


Note that the frequencies given in the graph above are absolute ones, while the frequencies given in Figure 2.16(a) of *Principles of Econometrics, 4e* are relative ones.

Go back to your **br data** worksheet. In the **Histogram** dialog box**,** specify **D2:D1081** for the **Input Range** and **T2:T29** for the **Bin Range**. Check the **New Worksheet Ply** option and name it **lnPrice Histogram**; check the box next to **Chart Output**. Finally, select **OK**.



The final result is (see also Figure 2.16(b) on p. 72 in *Principles of Econometrics, 4e*):



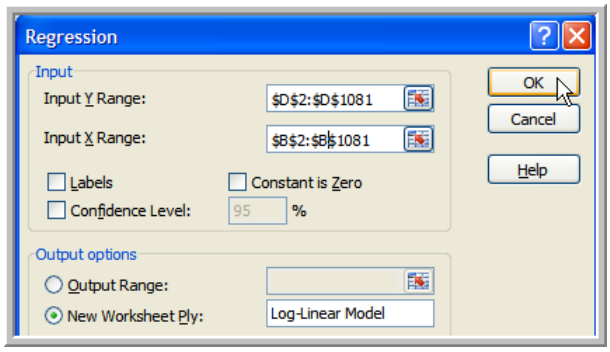
Again, note that the frequencies given in the graph above are absolute ones, while the frequencies given in Figure 2.16(b) of *Principles of Econometrics*, *4e* are relative ones.

2.6.2b Estimating the Model

We estimate the following log-linear model for house prices:

$$ln(PRICE) = \gamma_1 + \gamma_2 SQFT + e \tag{2.16}$$

In the **Regression** dialog box, the **Input Y Range** should be **D2:D1081**, and the **Input X Range** should be **B2:B1081**. Select **New Worksheet Ply** and name it **Log-Linear Model**. Finally select **OK**.



The result is (matching the one reported on p. 72 in *Principles of Econometrics*, *4e*):

	A	B	C	D	E	F	G	H	I
1	SUMMARY OUTPUT								
2									
3	*Regression Statistics*								
4	Multiple R	0.790413619							
5	R Square	0.624753689							
6	Adjusted R Square	0.624405594							
7	Standard Error	0.321465013							
8	Observations	1080							
9									
10	ANOVA								
11		*df*	*SS*	*MS*	*F*	*Significance F*			
12	Regression	1	185.4720974	185.4720974	1794.779738	1.1066E-231			
13	Residual	1078	111.4002553	0.103339754					
14	Total	1079	296.8723527						
15									
16		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
17	Intercept	10.83859632	0.024607484	440.459342	0	10.79031232	10.88688031	10.79031232	10.88688031
18	X Variable 1	0.000411269	9.70779E-06	42.36484082	1.1066E-231	0.000392221	0.000430317	0.000392221	0.000430317

2.6.2c Scatter of Data and Fitted Log-Linear Relationship

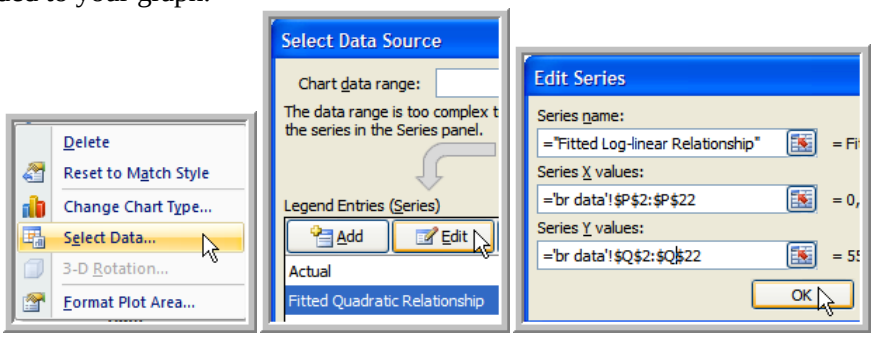
In cells **Q1:Q2** of your **br data** worksheet, enter the following column label and formula.

	Q
1	**log-linear price-hat**
2	=EXP('Log-Linear Model'!$B$17+'Log-Linear Model'!$B$18*'br data'!P2)

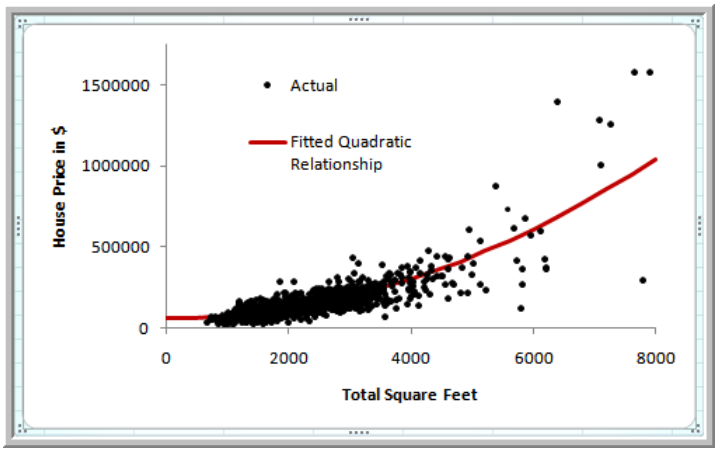
Next, copy the content of cells **Q2** to cells **Q3:Q22**. Here is how your table should look (only the first five values are shown below):

	Q
1	**log-linear price hat**
2	50949.81045
3	60060.27135
4	70799.79617
5	83459.68183
6	98383.31279

Select your scatter plot of actual data points and fitted quadratic relationship and make a copy of it. Right-click in the middle of the copy of your chart. Select **Select Data**. In the **Legend Entries (Series)** window of the **Select Data Source** dialog box, select the **Fitted Quadratic Relationship** series, and then the **Edit** button. In the **Series name** window, replace the old name by **Fitted Log-Linear Relationship**. Select **P2:P22** for the **Series X values** and select **Q2:Q22** for the **Series Y values**. Finally, select **OK**, twice. The **Fitted Log-Linear Relationship** series has been added to your graph.



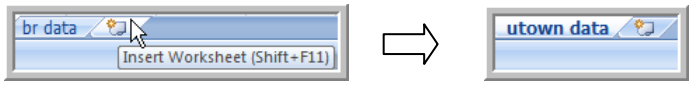
The result is (see also Figure 2.17 on p. 73 in *Principles of Econometrics, 4e*):



2.7 REGRESSION WITH INDICATOR VARIABLES

2.7.1 Histograms of House Prices

Open the Excel file ***utown***. Excel opens the data set in Sheet 1 of a new Excel file. Since we would like to save all our work from Chapter 2 in one file, create a new worksheet in your **POE Chapter 2** Excel file, name it **utown data**, and in it, copy the data set you just opened.

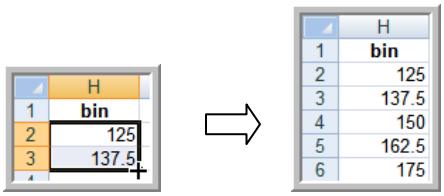


This data file contains a sample of 1000 observations on house prices in two neighborhoods. One neighborhood is near a major university and called University Town. Another similar neighborhood, called Golden Oaks, is a few miles away from the university.

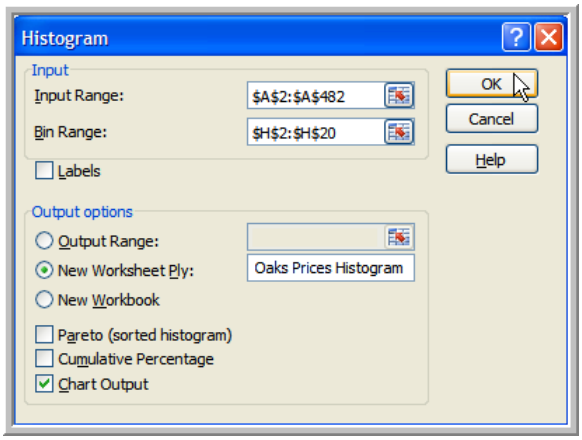
In cells **H1:H3** of your **utown data** worksheet, enter the following column label and data.

	H
1	**bin**
2	125
3	137.5

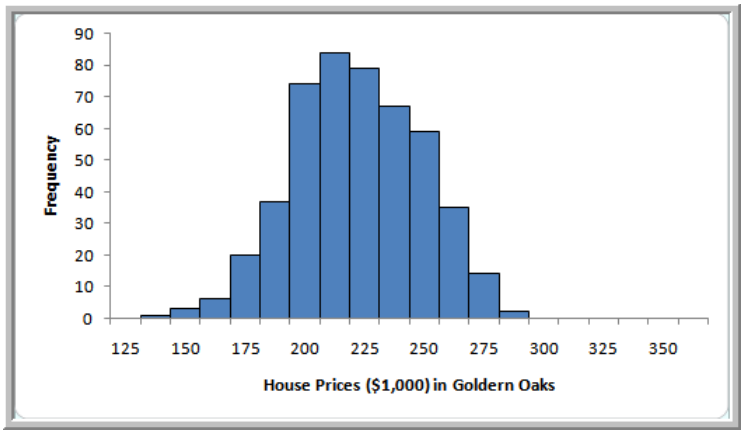
Select cells **H2:H3**, move your cursor to the lower right corner of your selection until it turns into a skinny cross as shown below; left-click, hold it and drag it down to cell **H20**. Here is how your table should look (only the first five values are shown below):



In the **Histogram** dialog box**,** specify **A2:A482** for the **Input Range** and **H2:H20** for the **Bin Range**. Check the **New Worksheet Ply** option and name it **Golden Oaks Prices Histogram**; check the box next to **Chart Output**. Finally, select **OK**.

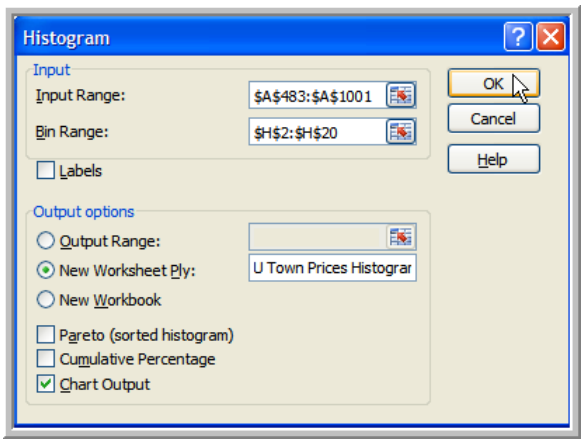


The final result is (see also Figure 2.18 on p. 74 in *Principles of Econometrics, 4e*):

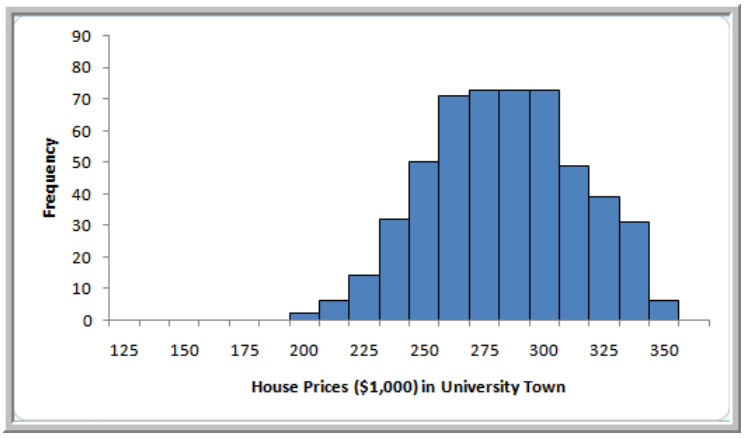


Note that the frequencies given in the graph above are absolute ones, while the frequencies given in Figure 2.18 of *Principles of Econometrics, 4e* are relative ones.

Go back to your **utown data** worksheet. In the **Histogram** dialog box**,** specify **A483:A1001** for the **Input Range** and **H2:H20** for the **Bin Range**. Check the **New Worksheet Ply** option and name it **U Town Prices Histogram**; check the box next to **Chart Output**. Finally, select **OK**.



The final result is (see also Figure 2.18 on p. 74 in *Principles of Econometrics, 4e*):



2.7.2 Estimating the Model

We estimate the following regression model for house prices

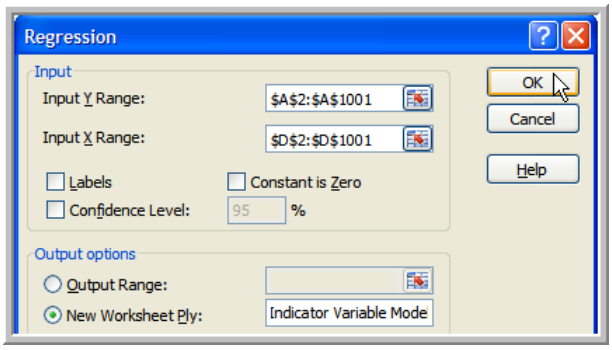
$$\boldsymbol{PRICE = \beta_1 + \beta_2 UTOWN + e} \tag{2.17}$$

The indicator variable is

$$UTOWN = \begin{cases} 0 & \text{house is in University Town} \\ 1 & \text{house is in Golden Oaks} \end{cases} \tag{2.18}$$

Go back to your **utown data** worksheet.

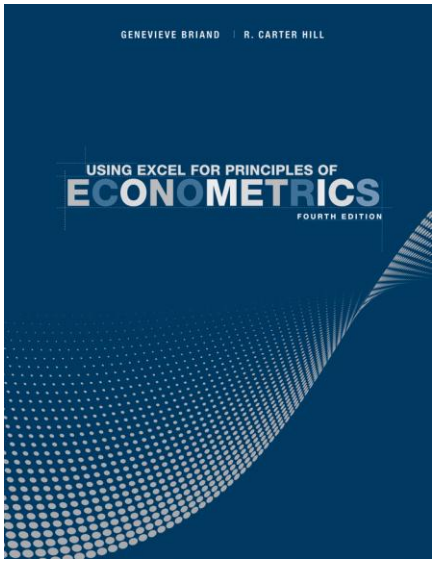
In the **Regression** dialog box, the **Input Y Range** should be **A2:A1001**, and the **Input X Range** should be **D2:D1001**. Select **New Worksheet Ply** and name it **Indicator Variable Model**. Finally select **OK**.



The result is (matching the one reported on p. 75 in *Principles of Econometrics*, *4e*):

	A	B	C	D	E	F	G	H	I
1	SUMMARY OUTPUT								
2									
3	*Regression Statistics*								
4	Multiple R	0.728744479							
5	R Square	0.531068516							
6	Adjusted R Square	0.530598645							
7	Standard Error	28.90745008							
8	Observations	1000							
9									
10	ANOVA								
11		*df*	*SS*	*MS*	*F*	*Significance F*			
12	Regression	1	944476.7538	944476.7538	1130.242684	2.6479E-166			
13	Residual	998	833969.3888	835.6406701					
14	Total	999	1778446.143						
15									
16		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
17	Intercept	215.7324947	1.318066269	163.6734812	0	213.1459956	218.3189939	213.1459956	218.3189939
18	X Variable 1	61.50910666	1.829589113	33.61908214	2.6479E-166	57.9188238	65.09938951	57.9188238	65.09938951

This ends Chapter 2 of this manual. You might want to save your work before you close shop.



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