

Introduction to Stata

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This is an updated version of Michal McMahon's Stata notes. He taught this course at the Bank of England (2008) and at the LSE (2006, 2007). It builds on earlier courses given by Martin Stewart (2004) and Holger Breinlich (2005). Any errors are my sole responsibility.

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Course Outline

This course is run over 8 weeks during this time it is not possible to cover everything – it never is with a program as large and as flexible as Stata. Therefore, I shall endeavour to take you from a position of complete novice (some having never seen the program before), to a position from which you are confident users who, through practice, can become intermediate and onto expert users.

In order to help you, the course is based around practical examples – these examples use macro data but have no economic meaning to them. They are simply there to show you how the program works. There will be some optional exercises, for which data is provided on my website – <http://personal.lse.ac.uk/lembcke>. These are to be completed in your own time, there should be some time at the end of each meeting where you can play around with Stata yourself and ask specific questions.

The course will follow the layout of this handout and the plan is to cover the following topics.

Week	Time/Place	Activity
Week 1	Tue, 17:30 – 19:30 (S169)	Getting started with Stata
Week 2	Tue, 17:30 – 19:30 (S169)	Database Manipulation and graphs
Week 3	Tue, 17:30 – 19:30 (S169)	More database manipulation, regression and post-regression analysis
Week 4	Tue, 17:30 – 19:30 (S169)	Advanced estimation methods in Stata
Week 5	Tue, 17:30 – 19:30 (S169)	Programming basics in Stata
Week 6	Tue, 17:30 – 19:30 (S169)	Writing Stata programs
Week 7	Tue, 17:30 – 19:30 (S169)	Mata
Week 8	Tue, 17:30 – 19:30 (S169)	Maximum Likelihood Methods in Stata

I am very flexible about the actual classes, and I am happy to move at the pace desired by the participants. But if there is anything specific that you wish you to ask me, or material that you would like to see covered in greater detail, I am happy to accommodate these requests.

Getting to Know Stata and Getting Started

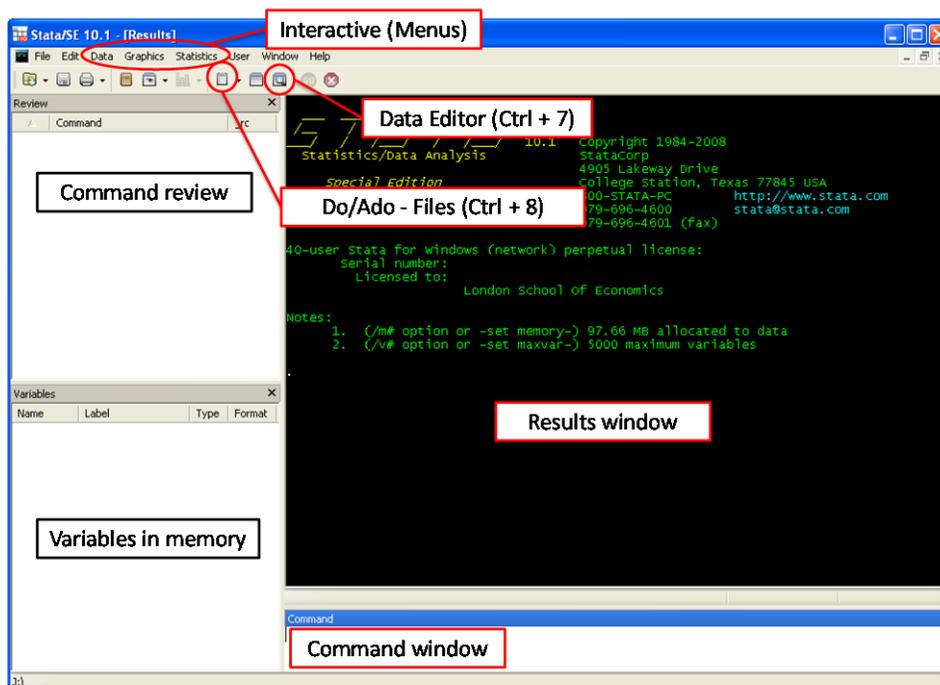
Why Stata?

There are lots of people who use Stata for their applied econometrics work. But there are also numerous people who use other packages (SPSS, Eviews or Microfit for those getting started, RATS/CATS for the time series specialists, or R, Matlab, Gauss, or Fortran for the really hardcore). So the first question that you should ask yourself is why should I use Stata?

Stata is an integrated statistical analysis packaged designed for research professionals. The official website is <http://www.stata.com/>. Its main strengths are handling and manipulating large data sets (e.g. millions of observations!), and it has ever-growing capabilities for handling panel and time-series regression analysis. The most recent version is Stata 10 and with each version there are improvements in computing speed, capabilities and functionality. It now also has pretty flexible graphics capabilities. It is also constantly being updated or advanced by users with a specific need – this means that even if a particular regression approach is not a standard feature, you can usually find someone on the web who has written a programme to carry-out the analysis and this is easily integrated with your own software.

What Stata looks like

On LSE computers the Stata package is located on a software server and can be started by either going through the Start menu (Start – Programs – Statistics – Stata10) or by double clicking on wsestata.exe in the W:\Stata10 folder. The current version is Stata 10. In the research centres the package is also on a server (\\st-server5\stata10\$), but you should be able to start Stata either from the quick launch toolbar or by going through Start – Programs.



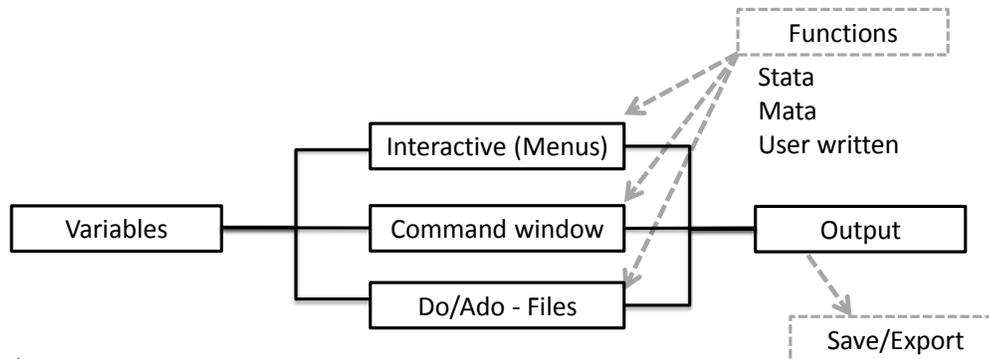
There are 4 different packages available: Stata MP (multi-processor) which is the most powerful, Stata SE (special edition), Intercooled STATA and Small STATA. The main difference between these versions is the maximum number of variables, regressors and observations that can be handled (see <http://www.stata.com/order/options-e.html#difference-sm> for details). The LSE is currently running the SE-version, version 10.

Stata is a command-driven package. Although the newest versions also have pull-down menus from which different commands can be chosen, the best way to learn Stata is still by typing in the commands. This has the advantage of making the switch to programming much easier which will be necessary for any serious econometric work. However, sometimes the exact syntax of a command is hard to get right –in these cases, I often use the menu-commands to do it once and then copy the syntax that appears.

You can enter commands in either of three ways:

- Interactively: you click through the menu on top of the screen
- Manually: you type the first command in the command window and execute it, then the next, and so on.
- Do-file: type up a list of commands in a “do-file”, essentially a computer programme, and execute the do-file.

The vast majority of your work should use do-files. If you have a long list of commands, executing a do-file once is a lot quicker than executing several commands one after another. Furthermore, the do-file is a permanent record of all your commands and the order in which you ran them. This is useful if you need to “tweak” things or correct mistakes – instead of inputting all the commands again one after another, just amend the do-file and re-run it. Working interactively is useful for “I wonder what happens if ...?” situations. When you find out what happens, you can then add the appropriate command to your do-file. To start with we’ll work interactively, and once you get the hang of that we will move on to do-files.



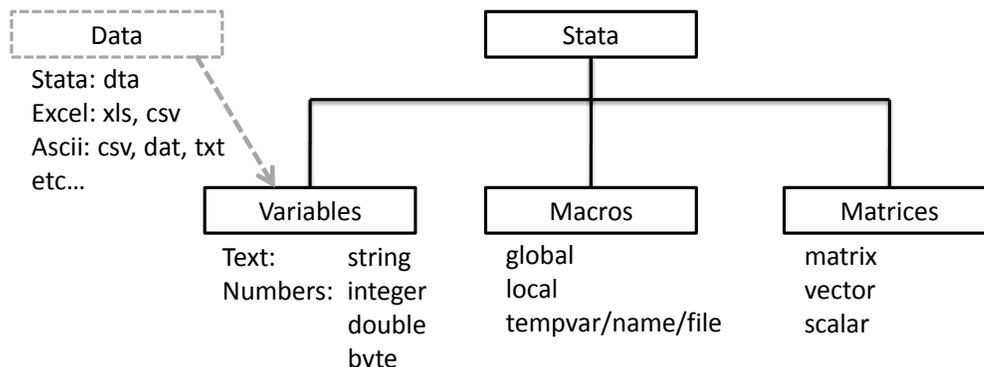
Data in Stata

Stata is a versatile program that can read several different types of data. Mainly files in its own dta format, but also raw data saved in plain text format (ASCII format). Every program you use (i.e. Excel or other statistical packages) will allow you to export your data in some kind of ASCII file. So you should be able to load all data into Stata.

When you enter the data in Stata it will be in the form of variables. Variables are organized as column vectors with individual observations in each row. They can hold numeric data as well as strings. Each row is associated with one observation, that is the 5th row in each variable holds the information of the 5th individual, country, firm or whatever information your data entails.

Information in Stata is usually and most efficiently stored in variables. But in some cases it might be easier to use other forms of storage. The other two forms of storage you might find useful are matrices and macros. Matrices have rows and columns that are not associated with any observations. You can for example store an estimated coefficient vector as a $k \times 1$ matrix (i.e. a column vector) or the variance matrix which is $k \times k$. Matrices use more memory than variables and the size of matrices is limited 11,000 (800 in Stata/IC), but your memory will probably run out before you hit that limit. You should therefore use matrices sparingly.

The third option you have is to use macros. Macros are in Stata what variables are in other programming languages, i.e. named containers for information of any kind. Macros come in two different flavours, local or temporary and global. Global macros stay in the system and once set, can be accessed by all your commands. Local macros and temporary objects are only created within a certain environment and only exist within that environment. If you use a local macro in a do-file it, you can only use it for code within that do-file.



Getting help

Stata is a command driven language – there are over 500 different commands and each has a particular syntax required to get any various options. Learning these commands is a time-consuming process but it is not hard. At the end of each class notes I shall try to list the commands that we have covered but there is no way we will cover all of them in this short introductory course. Luckily though, Stata has a fantastic options for getting help. In fact, most of your learning to use Stata will take the form of self-teaching by using manuals, the web, colleagues and Stata’s own help function.

Manuals

The Stata manuals are available in LSE library as well as in different sections of the research centres. – many people have them on their desks. The User Manual provides an overall view on using Stata. There are also a number of Reference Volumes, which are basically encyclopaedias of all the different commands and all you ever needed to know about each one. If you want to find information on a particular command or a particular econometric technique, you should first look up the index at the back of any manual to find which volumes have the relevant information. Finally, there are several separate manuals for special topics such as a Graphics Manual, a panel data manual (cross-sectional time-series) or one on survey data.

Stata’s in-built help and website

Stata also has an abbreviated version of its manuals built-in. Click on Help, then Contents. Stata’s website has a very useful FAQ section at <http://www.stata.com/support/faqs/>. Both the in-built help and the FAQs can be simultaneously searched from within Stata itself (see menu Help>Search). Stata’s website also has a list of helpful links at <http://www.stata.com/links/resources1.html>.

The web

As with everything nowadays, the web is a great place to look to resolve problems. There are numerous chat-rooms about Stata commands, and plenty of authors put new programmes on their websites. Google should help you here.

Colleagues

The other place where you can learn a lot is from speaking to colleagues who are more familiar with Stata functions than you are – the LSE is littered with people who spend large parts of their days typing different commands into Stata, you should make use of them if you get really stuck.

Textbooks

There are some textbooks that offer an applied introduction to statistical or econometric topics using Stata. A basic textbook is “An Introduction to Modern Econometrics using Stata” by Christopher F. Baum. Who has also a book on programming in Stata “An Introduction to Stata Programming” forthcoming.

A more advanced text is “Microeconometrics using Stata” by A. Colin Cameron and Pravin K. Trivedi, which will become available in the UK shortly.

The last part of this book is based on William Gould, Jeffrey Pitblado, and William Sibney “Maximum Likelihood Estimation with Stata”, a book focussing solely on the Stata `m1` command.

Directories and folders

Like Dos, Linux, Unix and Windows, Stata can organise files in a tree-style directory with different folders. You should use this to organise your work in order to make it easier to find things at a later date. For example, create a folder “data” to hold all the datasets you use, sub-folders for each dataset, and so on. You can use some Dos and Linux/Unix commands in Stata, including:

```
. cd "H:\ECStata"           - change directory to "H:\ECStata"
. mkdir "FirstSession"     - creates a new directory within the current one (here, H:\ECStata)
. dir                      - list contents of directory or folder (you can also use the linux/unix command: ls)
. pwd                      - displays the current directory
```

Note, Stata is case sensitive, so it will not recognise the command `CD` or `Cd`. Also, quotes are only needed if the directory or folder name has spaces in it – “H:\temp\first folder” – but it’s a good habit to use them all the time.

Another aspect you want to consider is whether you use absolute or relative file paths when working with Stata. Absolute file paths include the complete address of a file or folder. The `cd` command in the previous example is followed by an absolute path. The relative file path on the other hand gives the location of a file or folder relative to the folder that you are currently working in. In the previous example `mkdir` is followed by a relative path. We could have equivalently typed:

```
. mkdir "H:\ECStata\FirstSession"
```

Using relative paths is advantageous if you are working on different computers (i.e. your PC at home and a library PC or a server). This is important when you work on a larger or co-authored project, a topic we will come back to when considering project management. Also note that while Windows and Dos use a backslash “\” to separate folders, Linux and Unix use a slash “/”. This will give you trouble if you work with Stata on a server (ARC at the LSE). Since Windows is able to understand a slash as a separator, I suggest that you use slashes instead of backslashes when working with relative paths.

```
. mkdir "/FirstSession/Data" - create a directory “Data” in the folder H:\ECStata\FirstSession
```

Reading data into Stata

When you read data into Stata what happens is that Stata puts a copy of the data into the memory (RAM) of your PC. All changes you make to the data are only temporary, i.e. they will be lost once you close Stata, unless you save the data. Since all analysis is conducted within the limitations of the memory, this is usually the bottle neck when working with large data sets. There are different ways of reading or entering data into Stata:

use

If your data is in Stata format, then simply read it in as follows:

```
. use "H:\ECStata\G7 less Germany pwt 90-2000.dta", clear
```

The `clear` option will clear the revised dataset currently in memory before opening the other one. Or if you changed the directory already, the command can exclude the directory mapping:

```
. use "G7 less Germany pwt 90-2000.dta", clear
```

If you do not need all the variables from a data set, you can also load only some of the variables from a file.

```
. use country year using "G7 less Germany pwt 90-2000.dta", clear
```

insheet

If your data is originally in Excel or some other format, you need to prepare the data before reading it directly into Stata. You need to save the data in the other package (e.g. Excel) as either a csv (comma separated values ASCII text) or txt (tab-delimited ASCII text) file. There are some ground-rules to be followed when saving a csv- or txt-file for reading into Stata:

- The first line in the spreadsheet should have the variable names, e.g. series/code/name, and the second line onwards should have the data. If the top row of the file contains a title then delete this row before saving.
- Any extra lines below the data or to the right of the data (e.g. footnotes) will also be read in by Stata, so make sure that only the data itself is in the spreadsheet before saving. If necessary, select all the bottom rows and/or right-hand columns and

delete them.

- The variable names cannot begin with a number. If the file is laid out with years (e.g. 1980, 1985, 1990, 1995) on the top line, then Stata will run into problems. In such instances you can for example, place an underscore in front of each number (e.g. select the row and use the spreadsheet package's "find and replace" tools): 1980 becomes _1980 and so on.
- Make sure there are no commas in the data as it will confuse Stata about where rows and columns start and finish (again, use "find and replace" to delete any commas before saving – you can select the entire worksheet in Excel by clicking on the empty box in the top-left corner, just above 1 and to the left of A).
- Some notations for missing values can confuse Stata, e.g. it will read double dots (..) or hyphens (-) as text. Use find & replace to replace such symbols with single dots (.) or simply to delete them altogether.

Once the csv- or txt-file is saved, you then read it into Stata using the command:

```
. insheet using "H:\ECStata\G7 less Germany pwt 90-2000.txt", clear
```

Note that if we had already changed to H:\ECStata using the cd command, we could simply type:

```
. insheet using "G7 less Germany pwt 90-2000.txt", clear
```

There are a few useful options for the insheet command ("options" in Stata are additional features of standard commands, usually appended after the command and separated by a comma – we will see many more of these). The first option is `clear` which you can use if you want to insheet a new file while there is still data in memory:

```
. insheet using "H:\ECStata\G7 less Germany pwt 90-2000.txt", clear
```

Alternatively, you could first erase the data in memory using the command `clear` and then insheet as before.

The second option, `names`, tells Stata that the file you insheet contains the variable names in the first row. Normally, Stata should recognise this itself but sometimes it simply doesn't – in these cases `names` forces Stata to use the first line in your data for variable names:

```
. insheet using "F:\Stata classes\G7 less Germany pwt 90-2000.txt", names clear
```

Finally, the option `delimiter("char")` tells Stata which delimiter is used in the data you want to insheet. Stata's `insheet` automatically recognises tab- and comma-delimited data but sometimes different delimiters are used in datasets (such as ";"):

```
. insheet using "h:\wdi-sample.txt", delimiter(";")
```

infix

While comma separated or tab delimited data is very common today, older data is often saved in a fixed ASCII format. The data cannot be read directly but a codebook is necessary that explains how the data is stored. An example for data that is stored this way is the U.S. National Health Interview Survey (NHIS). The first two lines of one of the 1986 wave look like this:

```
10861096028901 05 011 1 02130103000000000000000000000001
10861096028902 05 011 1 02140103000000000000000000000001
```

The codebook (usually a pdf or txt file) that accompanies the data tells you that the first 2 numbers code the record type, the following 2 numbers are the survey year (here 1986), the fifth number is the quarter (here the first quarter) of the interview and so on.

To read this type of data into Stata we need to use the `infix` command and provide Stata with the information from the codebook.

```
. infix rectype 1-2 year 3-4 quarter 5 [...] using "H:\ECStata\NHIS1986.dat", clear
```

Since there are a lot of files it may be more convenient to save the codebook information in a separate file, a so called "dictionary file". The file would look like this:

```
infix dictionary using NHIS1986.dat {
    rectype      1-2
    year        3-4
    quarter      5
    [...]
}
```

After setting up this file we would save it as NHIS1986.dct and use it in the infix command. Note that we used a relative path in the dictionary file, i.e. by not stating a file path for NHIS1986.dat we assume that the raw data is located in the same directory as the dictionary file. With the dictionary file we do not need to refer to the data directly anymore:

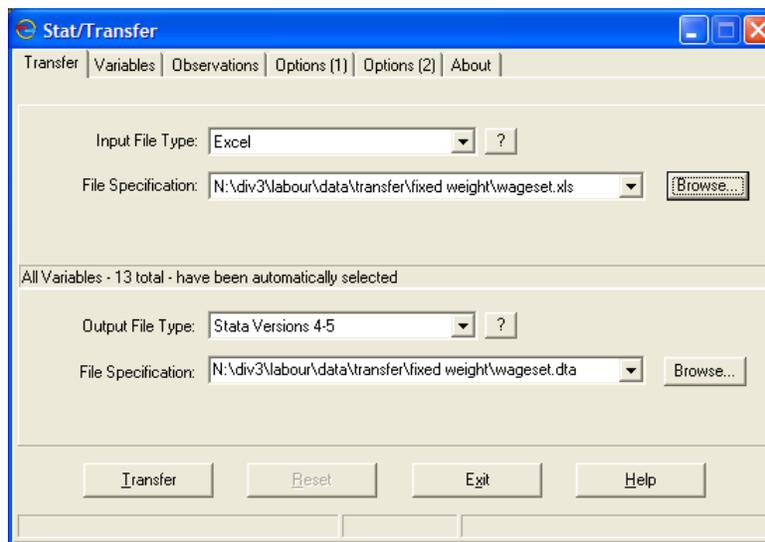
```
. infix using "H:\ECStata\NHIS1986.dct", clear
```

Since setting up dictionary files is a lot of work, we are lucky that for the NHIS there exists already a dictionary file that can be read with SAS (a program similar to Stata). After reading the data into SAS and saving it we can use a tool called Stat/Transfer to convert the file into the Stata data format.

Stat/Transfer program

This is a separate package that can be used to convert a variety of different file-types into other formats, e.g. SAS or Excel into Stata or vice versa. You should take great care to examine the converted data thoroughly to ensure it was converted properly.

It is used in a very user-friendly way (see screen shot below) and is useful for changing data between lots of different packages and format.



Manual typing or copy-and-paste

If you can open the data in Excel, you can usually copy and paste the data into the Stata data editor. All you need to do is select the columns in Excel; copy them; open the Stata data editor; and paste. This works usually quite well but entails certain pitfalls. The data format might not turn out to be correct, missing values might not be accounted for properly and in some cases language issues might arise (in some countries a comma rather than a decimal point is used).

Manually typing in the data is the tedious last resort – if the data is not available in electronic format, you may have to type it in manually. Start the Stata program and use the edit command – this brings up a spreadsheet-like where you can enter new data or edit existing data.

This can be done directly by typing the variables into the window, or indirectly using the input command.

Variable and data types

Indicator or data variables

You can see the contents of a data file using the `browse` or `edit` command. The underlying numbers are stored in “data variables”, e.g. the `cgdp` variable contains national income data and the `pop` variable contains population data. To know what each data-point refers to, you also need at least one “indicator variable”, in our case `countryisocode` (or `country`) and year tell us what country and year each particular `gdp` and population figure refers to. The data might then look as follows:

country	countryisocode	year	pop	cgdp	openc
Canada	CAN	1990	27700.9	19653.69	51.87665
France	FRA	1990	58026.1	17402.55	43.46339
Italy	ITA	1990	56719.2	16817.21	39.44491
Japan	JPN	1990	123540	19431.34	19.81217
United Kingdom	GBR	1990	57561	15930.71	50.62695
United States	USA	1990	249981	23004.95	20.61974

This layout ensures that each data-point is on a different row, which is necessary to make Stata commands work properly.

Numeric or string data

Stata stores or formats data in either of two ways – numeric or string. Numeric will store numbers while string will store text (it can also be used to store numbers, but you will not be able to perform numerical analysis on those numbers).

Numeric storage can be a bit complicated. Underneath its Windows platform, Stata, like any computer program, stores numbers in binary format using 1's and 0's. Binary numbers tend to take up a lot of space, so Stata will try to store the data in a more compact format. The different formats or storage types are:

`byte` : integer between -127 and 100 e.g. dummy variable

`int` : integer between -32,767 and 32,740 e.g. year variable

`long` : integer between -2,147,483,647 and 2,147,483,620 e.g. population data

`float` : real number with about 8 digits of accuracy e.g. production output data

`double` : real number with about 16 digits of accuracy

The Stata default is “float”, and this is accurate enough for most work. However, for critical work you should make sure that your data is “double”. Note, making all your numerical variables “double” can be used as an insurance policy against inaccuracy, but with large data-files this strategy can make the file very unwieldy – it can take up lots of hard-disk space and can slow down the running of Stata. Also, if space is at a premium, you should store integer variables as “byte” or “int”, where appropriate.

The largest 27 numbers of each numeric format are reserved for missing values. For `byte` the standard missing value is 101, which will be represented by a dot (.) in Stata. Later when we evaluate logic expressions we need to account for this.

String is arguably more straightforward – any variable can be designated as a string variable and can contain up to 244 characters, e.g. the variable `name` contains the names of the different countries. Sometimes, you might want to store numeric variables as strings, too. For example, your dataset might contain an indicator variable `id` which takes on 9-digit values. If `id` were stored in float format (which is accurate up to only 8 digits), you may encounter situations where different `id` codes are rounded to the same amount. Since we do not perform any calculations on `id` we could just as well store it in string format and avoid such problems.

To preserve space, only store a variable with the minimum string necessary – so the longest named `name` is “United Kingdom” with 14 letters (including the space). A quick way to store variables in their most efficient format is to use the `compress` command – this goes through every observation of a variable and decides the least space-consuming format without sacrificing the current level of accuracy in the data.

```
. compress
```

Missing values

Missing numeric observations are denoted by a single dot (.), missing string observations are denoted by blank double quotes (“”). For programming purposes different types of missing values can be defined (up to 27) but this will rarely matter in applied work.

Examining the data

It is a good idea to examine your data when you first read it into Stata – you should check that all the variables and observations are there and in the correct format.

List

As we have seen, the `browse` and `edit` commands start a pop-up window in which you can examine the raw data. You can also examine it within the results window using the `list` command – although listing the entire dataset is only feasible if it is small. If the dataset is large, you can use some options to make `list` more useable. For example, list just some of the variables:

```
. list country* year year pop
+-----+
|          country   countr~e   year      pop |
+-----+
1. |          Canada      CAN   1990   27700.9 |
2. |          France      FRA   1990   58026.1 |
3. |          Italy       ITA   1990   56719.2 |
4. |          Japan       JPN   1990   123540 |
5. | United Kingdom      GBR   1990    57561 |
+-----+
6. | United States       USA   1990   249981 |
7. |          Canada      CAN   1991   28030.9 |
8. |          France      FRA   1991   58315.8 |
9. |          Italy       ITA   1991   56750.7 |
10. |          Japan       JPN   1991   123920 |
+-----+
```

The star after “country” works as a place holder and tells Stata to include all variables that start with “country”.

Alternatively we could focus on all variables but list only a limited number of observations. For example the observation 45 to 49:

```
. list in 45/49
```

Or both:

```
. list country countryisocode year pop in 45/49
+-----+
|          country   countr~e   year      pop |
+-----+
45. |          Italy       ITA   1997   57512.2 |
46. |          Japan       JPN   1997   126166 |
47. | United Kingdom      GBR   1997    59014 |
48. | United States       USA   1997   268087 |
49. |          Canada      CAN   1998    30248 |
+-----+
```

Subsetting the data (if and in qualifiers)

In the previous section we used the “in” qualifier. The qualifier ensures that commands apply only to a certain subset of the data. The “in” qualifier is followed by a range of observations.

```
. list in 45/49
. list in 50/l
. list in -10/l
```

The first command lists observations 45 to 49, the second the observations from 50 until the last observation (lower case l) and the last command lists the last ten observations.

A second way of subsetting the data is the “if” qualifier (more on this later on). The qualifier is followed by an expression that evaluates either to “true” or “false” (i.e. 1 or 0). We could for example list only the observations for 1997:

```
. list if year == 1997
```

Browse/Edit

We have already seen that `browse` starts a pop-up window in which you can examine the raw data. Most of the time we only want to view a few variables at a time however, especially in large datasets with a large number of variables. In such cases, simply list the variables you want to examine after `browse`:

```
. browse name year pop
```

The difference with `edit` is that this allows you to manually change the dataset.

Assert

With large datasets, it often is impossible to check every single observation using `list` or `browse`. Stata has a number of additional commands to examine data which are described in the following. A first useful command is `assert` which verifies whether a certain statement is true or false. For example, you might want to check whether all population (`pop`) values are positive as they should be:

```
. assert pop>0
. assert pop<0
```

If the statement is true, `assert` does not yield any output on the screen. If it is false, `assert` gives an error message and the number of contradictions.

Describe

This reports some basic information about the dataset and its variables (size, number of variables and observations, storage types of variables etc.).

```
. describe
```

Note that you can use the `describe` command for a file that hasn't yet been read into Stata:

```
. describe using "H:\wdi-sample.dta"
```

Codebook

This provides extra information on the variables, such as summary statistics of numerics, example data-points of strings, and so on. Codebook without a list of variables will give information on all variables in the dataset.

```
. codebook country
```

Summarize

This provides summary statistics, such as means, standard deviations, and so on.

```
. summarize
```

Variable	Obs	Mean	Std. Dev.	Min	Max
country	0				
countryiso~e	0				
year	66	1995	3.18651	1990	2000
pop	66	98797.46	79609.33	27700.9	275423
cgdp	66	22293.23	4122.682	15930.71	35618.67
openc	66	42.54479	18.64472	15.91972	86.80463
csave	66	24.31195	5.469772	16.2536	37.80159
ki	66	23.52645	4.634476	17.00269	35.12778
grgdpc	66	1.582974	1.858131	-3.981008	5.172524

Note that `code` and `name` are string variables with no numbers, so no summary statistics are reported for them. Also, `year` is a numeric, so it has summary statistics. Additional information about the distribution of the variable can be obtained using the `detail` option:

```
. summarize, detail
```

Tabulate

This is a versatile command that can be used, for example, to produce a frequency table of one variable or a cross-tab of two variables.

```
. tab name
-----+-----
```

Name	Freq.	Percent	Cum.
Canada	10	14.29	14.29
France	10	14.29	28.57
Germany	10	14.29	42.86
Italy	10	14.29	57.14
Japan	10	14.29	71.43
United Kingdom	10	14.29	85.71
United States	10	14.29	100.00

```
-----+-----
Total |          70      100.00
```

We can use the `tabulate` command combined with the `sum(varname)` option to gain a quick idea of the descriptive statistics of certain subgroups. For example the average population of all G7 countries (except Germany) in all years:

```
. tab year, sum(pop)
-----+-----
```

year	Summary of POP		Freq.
	Mean	Std. Dev.	
1990	95588.034	81969.389	6
1991	96250.4	82904.603	6
1992	96930.667	83847.404	6
1993	97603.95	84778.438	6
1994	98222.017	85639.914	6
1995	98872.683	86510.583	6
1996	99462.834	87354.77	6
1997	100083.63	88256.404	6
1998	100676.85	89128.951	6
1999	101246.45	89981.306	6
2000	101834.58	90824.442	6

```
-----+-----
Total | 98797.464 79609.332 66
```

There are also options to get the row, column and cell percentages as well as chi-square and other statistics – check the Stata manuals or on-line help for more information. Another helpful command is `tabstat`. It gives similar results to `tabulate` when used in conjunction with the `sum()` option. The biggest advantage of `tabstat` is that it allows to save the results in special matrices, which can be used for other commands (we learn more about this later).

Inspect

This is another way to eyeball the distribution of a variable, including as it does a mini-histogram. It is also useful for identifying outliers or unusual values, or for spotting non-integers in a variable that should only contain integers.

```
. inspect cgdg
```

```
cgdg:                                     Number of Observations
-----                                     Total    Integers  Non-
                                             Integers Integers
|      #      #                          Negative   -         -         -
|      #      #                          Zero       -         -         -
|      #      #                          Positive   66        -         66
|      #      #                          Total     -----
|      #      #      #                    Missing   -         -         66
+-----+-----+-----+
15930.71      35618.67
(66 unique values)
```

Graph

Stata has very comprehensive graphics capabilities (type “help graph” for more details). You can graph a simple histogram with the command:

```
. graph twoway histogram cgdg
```

Or a two-way scatterplot using:

```
. graph twoway scatter cgdg pop
```

While graphs in Stata 9 and Stata 10 have the advantage of looking quite fancy, they are also very slow. Often, you just want to visualise data without actually using the output in a paper or presentation. In this case, it is useful to switch to version 7 graphics which are much faster:

```
. graph7 cgdg pop
```

Saving the dataset

The command is simply `save`:

```
. save "H:\ECStata\G7 less Germany pwt 90-2000.dta", replace
```

The `replace` option overwrites any previous version of the file in the directory you try saving to. If you want to keep an old version as back-up, you should save under a different name, such as “new_G7”. Note that the only way to alter the original file permanently is to save the revised dataset. Thus, if you make some changes but then decide you want to restart, just re-open the original file.

Preserve and restore

If you are going to make some revisions but are unsure of whether or not you will keep them, then you have two options. First, you can save the current version, make the revisions, and if you decide not to keep them, just re-open the saved version. Second, you can use the `preserve` and `restore` commands; `preserve` will take a “photocopy” of the dataset as it stands and if you want to revert back to that copy later on, just type `restore`.

Keeping track of things

Stata has a number of tools to help you keep track of what work you did to datasets, what's in the datasets, and so on.

Do-files and log-files

Instead of typing commands one-by-one interactively, you can type them all in one go within a do-file and simply run the do-file once. The results of each command can be recorded in a log-file for review when the do-file is finished running.

Do-files can be written in any text editor, such as Word or Notepad. Stata also has its own editor built in – click the icon along the top of the screen with the pad-and-pencil logo (although it looks like an envelope to me). Most do-files follow the following format:

```
clear
cd "c:\projects\project1\"
capture log close
log using class.log, replace
set more off
set memory 100m
```

LIST OF COMMANDS

```
log close
```

To explain the different commands:

`clear` – clears any data currently in Stata's memory. If you try opening a datafile when one is already open, you get the error message: `no; data in memory would be lost`

`cd c:\projects\project1\` - sets the default directory where Stata will look for any files you try to open and save any files you try to save. So, if you type `use wdi-sample.dta`, Stata will look for it in this folder. If, during the session, you want to access a different directory, then just type out its destination in full, e.g. `use "c:\data\production.dta"` will look for the file in the `c:\data` folder. Note again that if you use spaces in file or directory names, you must include the file path in inverted commas.

`capture log close` – closes any log-files that you might have accidentally left open. If there were no log-file actually open, then the command `log close` on its own would stop the do-file running and give the error message: `no log file open`. Using `capture` tells Stata to ignore any error messages and keep going.

`log using class1.log, replace` – starts a log-file of all the results. The `replace` option overwrites any log file of the same name, so if you re-run an updated do-file again the old log-file will be replaced with the updated results. If, instead, you want to add the new log-file to the end of previous versions, then use the `append` option.

`set more off` – when there are a lot of results in the results window, Stata pauses the do-file to give you a chance to review each page on-screen and you have to press a key to get more. This command tells Stata to run the entire do-file without pausing. You can then review the results in the log file.

`set memory 100m` – Stata's default memory may not be big enough to handle large datafiles. Trying to open a file that is too large returns a long error message beginning: `no room to add more observations`. You can adjust the memory size to suit. First check the size of the file using the `describe` command (remember that you can use `describe` for a file that hasn't yet been read into Stata). This reports the size of the file in bytes. Then `set memory` just a bit bigger. Note, setting it too large can take the PC's memory away from other applications and slow the computer down, so only set it as large as necessary. For example, `describe` using `"c:\data\WDI-sampe.dta"` reports the size of the file to be 2,730 bytes, so `set memory 1m` should be sufficient.

`log close` – closes the log file.

It is good practice to keep extensive notes within your do-file so that when you look back over it you know what you were trying to achieve with each command or set of commands. You can insert comments in several different ways:

```
//
```

Stata will ignore a line if it starts with two consecutive slashes (or with an asterisk `*`), so you can type whatever you like on that line. But while two consecutive slashes work anywhere in a line, i.e. you can start a comment after a command, an asterisk can only be used at the beginning. Note, comments are also useful for getting Stata to temporarily ignore commands – if you decide later to re-insert the command into your do-file, just delete the slashes or the asterisk.

```
/* */
```

You can place notes after a command by inserting it inside these pseudo-parentheses, for example:

```
. use "c:\data\WDI-sample.dta", clear /* opens 1998 production data */
```

These pseudo-parentheses are also useful for temporarily blocking a whole set of commands – place /* at the beginning of the first command, */ at the end of the last, and Stata will just skip over them all.

Lastly you can use three consecutive slashes which will result in the rest of the line being ignored and the next line added at the end of the current line. This comment is useful for splitting a very long line of code over several lines.

```
. graph twoway (scatter cgdppop if year == 1990) /// This combines two scatter plots
               (scatter cgdppop of year == 2000)
```

Labels

You can put labels on datasets, variables or values – this helps to make it clear exactly what the dataset contains.

A dataset label of up to 80 characters can be used to tell you the data source, it's coverage, and so on. This label will then appear when you describe the dataset. For example, try the following:

```
. label data " Data from Penn World Tables 6.1"
```

```
. describe
```

Variable names tend to be short – you can use up to 32 characters, but for ease of use it's best to stick to about 8 or 10 as a maximum. This can give rise to confusion about what the variable actually represents – what exactly is `gdppop` and in what units is it measured? Which is where variable labels, with a capacity of 80 characters, come in.

```
. label variable cgdppop "GDP per capita in constant international dollars"
```

It can also be helpful to label different values. Imagine countries were coded as numbers (which is the case in many datasets). In this case, a tabulation may be confusing – what country does 1 represent, or 2 or 3?

```
. tabulate code
```

code	Freq.	Percent	Cum.
1	10	33.33	33.33
2	10	33.33	66.67
3	10	33.33	100.00
Total	30	100.00	

It might be better to label exactly what each value represents. This is achieved by first “defining” a label (giving it a name and specifying the mapping), then associating that label with a variable. This means that the same label can be associated with several variables – useful if there are several “yes/no/maybe” variables, for example. The label name itself can be up to 32 characters long (e.g. `countrycode`), and each value label must be no more than 80 characters long (e.g. “France” or “Italy”).

```
. label define countrycode 1 "Canada" 2 "Germany" 3 "France"
```

```
. label values code countrycode
```

Now, the tabulation should make more sense:

```
. tabulate code
```

code	Freq.	Percent	Cum.
Canada	10	33.33	33.33
Germany	10	33.33	66.67
France	10	33.33	100.00
Total	30	100.00	

see what each code represents, use `codebook` or:

```
. label list countrycode
countrycode:
      1 Canada
      2 Germany
      3 France
```

Notes

You can also add Post-it notes to your dataset or to individual variables to, for example, remind you of the source of the data, or to remind you of work you did or intend to do on a variable.

```
. note: data from PWT
. note cgdp: This is per capita variable
```

You can also time-stamp these notes:

```
. note cgdp: TS need to add Germany to complete the G7
```

Review your notes by simply typing notes:

```
. notes

_dta:
  1. data from PWT

cgdp:
  1. This is per capita variable
  2. 15 Feb 2006 13:01 need to add Germany to complete the G7
```

Stata will also tell you that there are notes when you use describe:

```
. describe
```

You can also delete notes. To drop all notes attached to a variable:

```
. note drop cgdp
```

To drop just one in particular:

```
. note drop cgdp in 2
```

Review

One final tool for keeping track is reviewing a list of previous commands. To see the last four, for example:

```
. #review 4
```

This is especially useful if you are working in interactive mode on a “what happens if...”. When you are happy with the sequence of commands you’ve tried, you can `review`, then cut and paste into your do-file.

Some shortcuts for working with Stata

- Most commands can be abbreviated, which saves some typing. For example: `summarize` to `sum`, `tabulate` to `tab`, `save` to `sa`. The abbreviations are denoted by the underlined part of the command in Stata help or the Stata manuals.
- You can also abbreviate variable names when typing. This should be used with caution, as Stata may choose a variable different to the one you intended. For example, suppose you have a dataset with the variables `pop`, `popurban` and `poprural`. If you want summary statistics for `popurban`, the command `sum pop` will actually give statistics for the `pop` variable. An alternative is to type in part of the variable name and then hit the tabulator key. Stata will fill in the rest of the variable name until ambiguity arises. In this example typing in `po` and hitting the tabulator key results in Stata putting in `pop`, typing in `popr` and hitting the tab key will give `poprural`.
- Stata's default file type is `.dta`, so you don't need to type that when opening or saving Stata files:
`sa "G7 less Germany pwt 90-2000"` is the same as `sa "G7 less Germany pwt 90-2000.dta"`
- You can save retyping commands or variable names by clicking on them in the review and variable windows – they will then appear in the command window. You can also cycle back and forth through previous commands using the PageUp and PageDown keys on your keyboard. Similarly, variable names can be easily entered by clicking on them in the Variables Window (bottom-left of the screen).
- Over time, you will find yourself using the same commands or the same sequence of commands again and again, e.g. the list of commands at the beginning of a log-file. Save these in a "common commands" text file from which you can cut and paste into your do-files.

A note on working empirical projects.

When you start working on an empirical project you will quite quickly accumulate a large number of do files, data sets, log files and other output. To keep track of things you should use comments throughout your do files that remind you of what the do file does, when you created it, when you last changed it, what links it has to other do files, etc. When saving files add the date they were created to them (e.g. 20081005 for the 5th of October 2008) and sort files into different folders. I keep one folder for do files, another for data and a third folder to export results and save log files.

If you are working with large data sets, the UK Labour Force Survey, the U.S. Current Population Survey, etc. memory, or rather the lack thereof becomes a problem rather quickly. The memory problem is aggravated by a curious (and apparently unsolvable) hard limit on the amount of memory that can be allocated to Stata when using Windows XP (32-bit). The limit is around 1.2 gb of memory, no matter how much actual memory your PC has. But two or even three gigabytes of memory might not suffice for your projects. The first thing you should do when running into the memory threshold is to drop everything from the dataset that you do not need for your analysis. You can always reload the original data set once you ran a particular regression (though this might be a fairly slow procedure). Use the `compress` command. You will not lose any information by doing so, but potentially save some space. If everything else fails, you can apply for an ARC account. ARC is a Unix server that runs Stata (among other statistical programs). But disk space and computation time is scarce so you should only use ARC as a last resort. You can find more information on ARC at the LSE itservice website: <http://www.lse.ac.uk/itservices/help/itsupport/ARC/default.htm>.

And last but not least: Never forget to backup your work!

If you use Stata regularly you might want to think about integrating Stata with an external editor. An excellent choice for Windows is WinEdt (<http://www.winedt.com>). WinEdt is mainly used for writing Latex documents but allows Stata command highlighting by installing an add on (<http://www.winedt.org/Config/modes/Stata.php>). If you want to use Stata and Latex with WinEdt I recommend you install another add on called "Auto Mode" (see my website for details). If you do not want to pay the \$30 license fees, you can also use free alternatives such as Notepad ++ (again see my website for details).

Database Manipulation

Now we are going to take the data that is in a form that Stata understands and we will organise those datasets by combining many together into a single large dataset, deleting unwanted variables, and also creating some new variables. Finally, we will learn a few techniques to close gaps in your data (extrapolation, splicing).

Organising datasets

Rename

You may want to change the names of your variables, perhaps to make it more transparent what the variable is:

```
. rename countryisocode country_code  
. ren grgdpch gdp_growth
```

Note, you can only rename one variable at a time.

Recode and replace

You can change the values that certain variables take, e.g. suppose 1994 data actually referred to 1924:

```
. recode year (1994 = 1924)
```

This command can also be used to recode missing values to the dot that Stata uses to denote missings. And you can recode several variables at once. Suppose a dataset codes missing population and gdp figures as -999:

```
. recode pop cgdp (-999 = .)
```

recode can not only several variables but several changes at the same time. We could for example use recode to generate a new variable with categorical population values, 1 for countries with less than 50 million inhabitants, 2 for 50 to 100 million and 3 for more than 100 million inhabitants.

```
. recode pop (0 / 50000 = 1) (50001 / 100000 = 2) (100000 / 7000000 = 3)
```

With string variables, however, you need to use the replace command (see more on this command below):

```
. replace country="United Kingdom" if country_code == "GBR"
```

Mvdecode and mvencode

A lot of datasets nowadays are readily available in Stata format. The UK Labour Force Survey for example. But while the data is easily read into Stata, the handling of missing values is another matter. Often missing values are not denoted by one of Stata's reserved values for missings (i.e. a dot), but by specific numbers. In the LFS for example this can be a value of -9 or -8 (depending on whether the question does not apply to a certain individual or whether the question was not answered). To replace all the missings quickly for all variables we can use the mvdecode command.

```
mvdecode cgdp year pop, mv(-8 -9)
```

This will replace all values of -8 and -9 in the three variables with the Stata missing value "."

Keep and drop (including some further notes on if-processing)

The original dataset may contain variables you are not interested in or observations you don't want to analyse. It's a good idea to get rid of these first – that way, they won't use up valuable memory and these data won't inadvertently sneak into your analysis. You can tell Stata to either `keep` what you want or `drop` what you don't want – the end results will be the same. For example, we can get rid of unwanted variables as follows:

```
. keep country year pop cgdp
```

or

```
. drop country_code openc csave ki grgdpch
```

or

```
. drop country_code openc - gdp_growth
```

Each of these will leave you with the same set of variables. Note that the hyphen sign (-) is a useful shortcut, e.g. the first one indicates all the variables between `openc` and `gdp_growth` are to be dropped. However, you must be careful that the order of the variable list is correct, you don't want to inadvertently drop a variable that you thought was somewhere else on the list. The variable list is in the variables window or can be seen using either the `desc` or `sum` commands.

You can also drop or keep observations, such as those after or before 1995:

```
. keep if year >= 1995
```

or

```
. drop if year < 1995
```

Note that missing values of numeric variables are treated as a large positive number, so both commands would keep not only all observations for 1995 and after but also all observations with missing values in the `year` variable.

The different relational operators are:

```
==      equal to
!=      not equal to
>       greater than
>=      greater than or equal to
<       less than
<=      less than or equal to
```

Keeping observations for the years 1990 to 1995 only:

```
. keep if (year>=1990 & year<=1995)
```

or

```
. drop if (year<1990 | year>1995)
```

Or, to get really fancy, keep the observations for 1990-95 and 1997-99:

```
. keep if ((year>=1990 & year<=1995) | (year>=1997 & year<=1999))
```

Note, the different logical operators are:

```
&       and
|       or
~       not
!       not
```

You may want to drop observations with specific values, such as missing values (denoted in Stata by a dot):

```
. drop if pop == .
```

Sometimes it is convenient to use a shorthand notation and leave out the operators:

```
. drop if pop
```

is short for

```
. drop if pop~=0
```

that is we drop all the observations where a population of zero is reported.

You may want to keep observations for all countries other than those for Italy:

```
. drop if country_code != "ITA"
```

Note, with string variables, you must enclose the observation reference in double quotes. Otherwise, Stata will think that `ITA` refers to a variable and claim not to be able to find what you are referring to.

If you know the observation number, you can selectively keep or drop different observations. Dropping observations 1 to 10:

```
. drop if _n <= 10
```

Dropping the last observation (number `_N`) in the dataset:

```
. drop if _n == _N
```

Both `_n` and `_N` are inbuilt system variables. The upper case `N` refers to the last number of observation. Combined with the `by` (see below) this can be the number of the last observation in a subset rather than the whole data. Lower case `n` always refers to the number of each observation (combined with `by`, this can be again a relative relation).

Finally, you may want to keep only a single occurrence of a specific observation type, e.g. just the first observation of each country code we can use Stata's indexing capabilities. A variable name followed by square brackets means that we want to refer to a certain observation, this can be an absolute value `[1]` would mean the first observation or `[_N]` the last observation or a relative index `[_n]` means the current and `[_n-1]` the observation before the current observation. To keep only the first occurrence of each country we can use:

```
. keep if country[_n]~=country[_n-1]
```

or simply

```
. keep if country~=country[_n-1]
```

Stata starts at observation number one and applies the command, then moves onto observation two and applies the command again, then onto three and so on. So, starting at one `_n=1` but there is no observation `_n-1 = 0`, so the country in one cannot equal the country in zero (which is missing: `""`) and the observation will be kept. Moving on to two: the country in two equals the country in one (both `AGO`), so the observation will be dropped. Each subsequent observation with country `AGO` will also be dropped. When we get to an observation with a different country (which will be `ALB`), the two countries will be different (`AGO~=ALB`) and the observation will be kept. Thus, we will end up being left with just the first observation for each country.

Sort

From the previous example, hopefully you will have realised the importance of the order of your observations. If the country codes had started out all jumbled up, then we would have ended up with a completely different set of observations. Suppose we applied the above command to the following dataset:

Number in dataset	country	Result
1	AGO	Kept since <code>_n=0</code> does not exist
2	AGO	Dropped since <code>country==country[n-1]</code>
3	ALB	Kept
4	ALB	Dropped
5	AGO	Kept
6	ALB	Kept
7	BEL	Kept

We would actually end up with numerous occurrences of some country codes. This shows how sorting the data first is important:

```
. sort country
```

If you wanted to make sure the observation that was kept was the earliest (i.e. 1950), then first:

```
. sort country year
```

This command first sorts the data by country, and then within each country code it sorts the data by year. This ensures that the first observation for every country (the one that is kept) will be 1950.

Note that sorting is in ascending order (A,B,C or 1950, 1951, 1952). To sort in descending order, you need to use the `gsort` command:

```
. gsort -country
```

This gives `ZWE` first, then `ZMB`, `ZAR`, `ZAF`, `YEM` and so on. Note that you need to place a minus sign before every variable you want to sort in descending order. This command allows you to sort in complicated ways, e.g. to sort country codes in descending order but then years in ascending order:

```
. gsort -country year
```

By-processing

You can re-run a command for different subsets of the data using the `by` prefix. For example, to get summary statistics of population broken down by year:

```
. sort year
. by year: sum pop
```

Note that you have to either sort the data first or use the `bysort` prefix:

```
. bysort year: sum pop
```

The `by` prefix causes the `sum` command to be repeated for each unique value of the variable `year`. The result is the same as writing a list of `sum` commands with separate `if` statements for each year:

```
. sum pop if year==1990
. sum pop if year==1991
. sum pop if year==1992
. sum pop if year==1993
. sum pop if year==1994
```

By-processing can be useful when organising your dataset. In our sort examples above we asked Stata to keep only the first observation for each country. The `by` command makes this selection a lot easier:

```
. bysort country: keep in 1
```

or equivalently

```
. bysort country: keep if _n == 1
```

Both commands will keep the first observation of each subset, i.e. the first observation for each country. But this is not necessarily the earliest observation. To ensure that we select the first year for each country we need to sort within the `by`-group (country) we selected:

```
. bysort country (year): keep in 1
```

The parentheses tell Stata to sort within country rather than opening up a different `by` group:

bysort country		bysort country (year)		bysort country year	
AGO	2000	AGO	1990	AGO	1990
AGO	1990	AGO	2000	AGO	2000
ALB	1990	ALB	1990	ALB	1990
ALB	2000	ALB	2000	ALB	2000

Append, merge and joinby

You can combine different datasets into a single large dataset using the `append`, `merge` and `joinby` commands. `append` is used to add extra observations (rows). Suppose you have two datasets containing the G7 less Germany PWT data for different countries and/or different years. The datasets have the same variables `country` / `year` / `pop` / etc, but one dataset has data for 1970-1990 (called "G7 less Germany pwt 70-90.dta") and the other has data for 1975-1998 (called "G7 less Germany pwt 90-2000.dta").

```
. use "H:\ECStata\G7 less Germany pwt 90-2000.dta", clear
. append using "H:\ECStata\G7 less Germany pwt 70-90.dta"
. save "H:\ECStata\G7 less Germany pwt.dta", replace
```

Append		
CTRY	YEAR	C-GDP
USA	1990	23,004
GBR	1990	15,930

CTRY	YEAR	C-GDP
USA	2000	35,618
GBR	2000	24,252

CTRY	YEAR	C-GDP
USA	1990	23,004
GBR	1990	15,930
USA	2000	35,618
GBR	2000	24,252

`append` is generally very straightforward. There is one important exception, however, if the two datasets you want to append have stored their variables in different formats (meaning string vs. numeric – having different numeric formats, for example byte vs. float, does not matter). In this case, Stata converts the data in the file to be appended to the format of the original file and in the process replaces all values to missing! To detect such problems while using `append`, watch out for messages like:

```
. (note: pop is str10 in using data but will be float now)
```

This indicates that a variable (here: `pop`) has been transformed from string to float – and contains all missing values now for the appending dataset (here: all years 1970-1990). It is thus very important to check via `describe` that the two files you intend to append have stored all variables in the same broad data categories (string/numeric). If this is not the case, you will need to transform them first (see the commands `destring` and `tostring` below).

`merge` is used to add extra variables (columns). Suppose we now also have a second dataset containing the same indicator variables `country / year`, but one dataset has data for GDP per capita and other variables, and the second has data for shares in GDP per capita of consumption and investment.

Merge (1-to-1)			
CTRY	YEAR	C-GDP	
USA	1990	23,004	
GBR	1990	15,930	

CTRY	YEAR	POP	
USA	1990	250	
GBR	1990	58	

CTRY	YEAR	C-GDP	Pop
USA	1990	23,004	250
GBR	1990	15,930	58

Merge (1-to-n)				
CTRY	YEAR	C-GDP	Pop	
USA	1990	23,004	250	
GBR	1990	15,930	58	
USA	2000	35,618	275	
GBR	2000	24,253	189	

YEAR	UN-M
1990	159
2000	189

CTRY	YEAR	C-GDP	Pop	UN-M
USA	1990	23,004	250	159
GBR	1990	15,930	58	159
USA	2000	35,618	275	189
GBR	2000	24,253	189	189

You must first ensure that both datasets are sorted by their common indicator variables, then `merge` according to these variables.

```
. use "H:\ECStata\G7 less Germany pwt.dta", clear
. sort country year
. save "H:\ECStata\G7 less Germany pwt.dta", replace
. use "H:\ECStata\G7 extra data.dta", clear /* "master" data */
. sort country year
. merge country year using "H:\ECStata\G7 less Germany pwt.dta" /*"using" data */
. tab _merge /* 1= master, 2= using, 3= both */
```

Stata automatically creates a variable called `_merge` which indicates the results of the merge operation. It is crucial to tabulate this variable to check that the operation worked as you intended. The variable can take on the values:

- 1 : observations from the master dataset that did not match observations from the using dataset
- 2 : observations from the using dataset that did not match observations from the master dataset
- 3 : observations from the both datasets that matched

Ideally, all observations will have a `_merge` value of 3. However, it may be possible, for instance, that the master dataset has observations for extra countries or extra years. If so, then some observations will have a `_merge` value of 1. You should tabulate these to confirm what the extra observations refer to:

```
. tab country if _merge==1
. tab year if _merge==1
. tab _merge
```

_merge	Freq.	Percent	Cum.
1	31	10.95	10.95
3	252	89.05	100.00
Total	283	100.00	

`tab country if _merge==1` then reveals that these extra observations are for the country "GER" or Germany. Now see if you can successfully incorporate the data on Germany between 1970-2000 for all of these variables. Look at help for how to do it.

Finally, `joinby` joins, within groups formed by the variables list behind the command, observations of the dataset in memory with another Stata-format dataset. "join" means "form all pairwise combinations". For example, you might have an industry classification (both codes and names) in one file and corresponding tariff rates in another (with only codes and tariff rates). Tariff rates vary across time but the industry classification does not. Now, you would like to match every industry with a time series of tariffs and also know what the different industry codes stand for. Since the classification data does not contain a year variable, you cannot use `merge` (unless you create a year variable and `expand` the data first which we will learn how to do later on). However, if you type

```
. joinby indclass using tariffs.dta
```

this will create all possible combinations between `indclass` (the variable that contains the different classification categories) and `year`. If the master and using dataset contain common variables, `joinby` will use the master contents. Also, observations unique to one or the other datasets are ignored, unless you overrule this using the option `unmatched` (see help `joinby` for details).

Collapse

This command converts the data into a dataset of summary statistics, such as sums, means, medians, and so on. One use is when you have monthly data that you want to aggregate to annual data:

```
. collapse (sum) monthpop, by(country year)
```

or firm-level data that you want to aggregate to industry level:

```
. collapse (sum) firmoutput, by(industry year month)
```

`by()` excludes the indicator variable that you are collapsing or summing over (`month` in the first example, `firm` in the second) – it just contains the indicator variables that you want to collapse by. Note that if your dataset contains other variables beside the indicator variables and the variables you are collapsing, they will be erased.

One possible problem that arises in the use of `collapse` is in its treatment of missings. It returns the summary statistic of missing values as zero. If, for example, when using the PWT Afghanistan ("AFG") contains all missing values for `pop`. If you wanted to aggregate population data over time (for whatever reasons), `collapse` would report aggregate population for Afghanistan as zero, not missing. If, instead, you want aggregate population figures to be missing if any or all of the year data is missing, then use the following coding (the technicalities of it will become clearer later, after you learn how to create dummy variables):

```
. gen missing=(pop==.)
. collapse (sum) pop missing, by(countrygroup)
. replace firmoutput=. if missing>0
. rename pop aggpob
. drop missing
```

Note, if you are running this command on a large dataset, it may be worthwhile to use the `fast` option – this speeds things up skipping the preparation of a backup if the command is aborted by the user pressing `BREAK`, but this is really only useful for when you are working interactively).

Order, aorder, and move

These commands can be used to do some cosmetic changes to the order of your variable list in the variables window, e.g. if you want to have the indicator variables on top of the list. `aorder` alphabetically sorts variables and `order` brings them in a user-specified order:

```
. aorder
. order countrycode year pop
```

If you do not list certain variables after `order`, they will remain where they are. `move` is used if you simply want to swap the position of two variables, e.g. bringing `year` to the top:

```
. move year countrycode
```

Creating new variables

Generate, egen, replace

The two most common commands for creating new variables are `gen` and `egen`. We can create a host of new variables from the existing data with the `gen` command:

```
. gen realgdp=(pop*1000)*cgdg          /* real GDP in current prices */
. gen lpop=ln(pop)                    /* log population */
. gen popsq=pop^2                     /* squared population */
. gen ten=10                           /* constant value of 10 */
. gen id=_n                            /* id number of observation */
. gen total=_N                         /* total number of observations */
. gen byte yr=year-1900                /* 50,51,etc instead of 1950,1951 */
. gen str6 source="PWT6.1"            /* string variable */
. gen largeyear=year if pop>5000 & pop!=.
```

A couple of things to note. First, Stata's default data type is float, so if you want to create a variable in some other format (e.g. byte, string), you need to specify this. Second, missing numeric observations, denoted by a dot, are interpreted by Stata as a very large positive number. You need to pay special attention to such observations when using `if` statements. If the last command above had simply been `gen largeyear=year if pop>5000`, then `largeyear` would have included observations 1950–1959 for AGO, even though data for those years is actually missing.

The `egen` command typically creates new variables based on summary measures, such as sum, mean, min and max:

```
. egen totalpop=sum(pop), by(year)     /* world population per year */
. egen avgpop=mean(pop), by(year)     /* average country pop per year */
. egen maxpop=max(pop)                /* largest population value */
. egen countpop=count(pop)            /* counts number of non-missing obs */
. egen groupid=group(country_code)    /* generates numeric id variable for countries */
```

The `egen` command is also useful if your data is in long format (see below) and you want to do some calculations on different observations, e.g. `year` is long, and you want to find the difference between 1995 and 1998 populations. The following routine will achieve this:

```
. gen temp1=pop if year==1995
. egen temp2=max(temp1), by(country_code)
. gen temp3=pop-temp2 if year==1998
. egen diff=max(temp3), by(country)
. drop temp*
```

Note that both `gen` and `egen` have `sum` functions. `egen` generates the total sum, and `gen` creates a cumulative sum. The running cumulation of `gen` depends on the order in which the data is sorted, so use it with caution:

```
. egen totpop=sum(pop)                /* sum total of population = single result*/
. gen cumpop=sum(pop)                 /* cumulative total of population */
```

To avoid confusion you can use the `total` function rather than `sum` for `egen`. It will give you the same result.

As with `collapse`, `egen` has problems with handling missing values. For example, summing up data entries that are all missing yields a total of zero, not missing (see `collapse` below for details and how to solve this problem).

The `replace` command modifies existing variables in exactly the same way as `gen` creates new variables:

```
. gen lpop=ln(pop)
. replace lpop=ln(1) if lpop==. /* missings now ln(1)=0 */
. gen byte yr=year-1900
. replace yr=yr-100 if yr >= 100 /* 0,1,etc instead of 100,101 for 2000 onwards */
```

Converting strings to numerics and vice versa

As mentioned before, Stata cannot run any statistical analyses on string variables. If you want to analyse such variables, you must first `encode` them:

```
. encode country, gen(ctyno)
. codebook ctyno          /* Tells you the link with the data* /
```

This creates a new variable `ctyno`, which takes a value of 1 for CAN, 2 for FRA, and so on. The labels are automatically computed, based on the original string values – you can achieve similar results but without the automatic labels using `egen ctyno=group(country)`.

You can go in the other direction and create a string variable from a numerical one, as long as the numeric variable has labels attached to each value:

```
. decode ctyno, gen(ctycode)
```

If you wanted to convert a numeric with no labels, such as `year`, into a string, the command is:

```
. tostring year, generate(yearcode)
```

And if you have a string variable that only contains numbers, you can convert them to a numeric variable using:

```
. destring yearcode, generate(yearno)
```

This last command can be useful if a numeric variable is mistakenly read into Stata as a string. You can confirm the success of each conversion by:

```
. desc country ctyno ctycode year yearcode yearno
```

Combining and dividing variables

You may wish to create a new variable whose data is a combination of the data values of other variables, e.g. joining country code and year to get AGO1950, AGO1951, and so on. To do this, first convert any numeric variables, such as `year`, to string (see earlier), then use the command:

```
. gen str7 ctyyear=country_code+yearcode
```

If you want to create a new numeric combination, first convert the two numeric variables to string, then create a new string variable that combines them, and finally convert this string to a numeric:

```
. gen str4 yearcode=string(year)
. gen str7 popcode=string(pop)
. gen str11 yearpopcode=yearcode+popcode
. gen yearpop=real(yearpopcode)

. sum yearpopcode yearpop /* displays the result */
```

To divide up a variable or to extract part of a variable to create a new one, use the `substr` function. For example, you may want to reduce the `year` variable to 70, 71, 72, etc. either to reduce file size or to merge with a dataset that has `year` in that format:

```
. gen str2 yr=substr(yearcode,3,2)
```

The first term in parentheses is the string variable that you are extracting from, the second is the position of the first character you want to extract (--X-), and the third term is the number of characters to be extracted (--XX). Alternatively, you can select your starting character by counting from the end (2 positions from the end instead of 3 positions from the start):

```
. gen str2 yr=substr(yearcode,-2,2)
```

Things can get pretty complicated when the string you want to divide isn't as neat as `yearcode` above. For example, suppose you have data on city population and that each observation is identified by a single variable called `code` with values such as "UK London", "UK Birmingham", "UK Cardiff", "Ireland Dublin", "France Paris", "Germany Berlin", "Germany Bonn", and so on. The `code` variable can be broken into country and city as follows:

```
. gen str10 country=substr(code,1,strpos(code," ")-1)
. gen str10 city=trim(substr(code, strpos(code," ")+1,11))
```

The `strpos()` function gives the position of the second argument in the first argument, so here it tells you what position the blank space takes in the `code` variable. The `country` substring then extracts from the `code` variable, starting at the first character, and extracting a total of $3-1=2$ characters for UK, $8-1=7$ characters for Ireland and so on. The `trim()` function removes any leading or trailing blanks. So, the `city` substring extracts from the `code` variable, starting at the blank space, and extracting a total of 11 characters including the space, which is then trimmed off. Note, the `country` variable could also have been created using `trim()`:

```
. gen str10 country=trim(substr(code,1, strpos(code, " ")))
```

Dummy variables

You can use `generate` and `replace` to create a dummy variable as follows:

```
. gen largepop=0
. replace largepop=1 if (pop>=5000 & pop!=. )
```

Or you can combine these in one command:

```
. gen largepop=(pop>=5000 & pop!=.)
```

Note, the parenthesis are not strictly necessary, but can be useful for clarity purposes. It is also important to consider missing values when generating dummy variables. With the command above a missing value in `pop` results in a 0 in `largepop`. If you want to keep missing values as missing, you have to specify an `if` condition:

```
. gen largepop=(pop>=5000 & pop!=.) if pop!=.
```

The `& pop!=.` part is not strictly necessary in this case, but it doesn't hurt to keep it there either.

You may want to create a set of dummy variables, for example, one for each country:

```
. tab country, gen(cdum)
```

This creates a dummy variable `cdum1` equal to 1 if the country is "CAN" and zero otherwise, a dummy variable `cdum2` if the country is "FRA" and zero otherwise, and so on up to `cdum7` for "USA". You can refer to this set of dummies in later commands using a wild card, `cdum*`, instead of typing out the entire list.

A third way to generate dummy variables is by using the `xi` prefix as a command.

```
. xi i.country
i.country      _Icountry_1-6      (_Icountry_1 for country==Canada omitted)
```

The command generates 5 dummy variables, omitting the sixth. This is useful to avoid a dummy variable trap (i.e. perfect multicollinearity of the intercept and a set of dummy variables) in a regression. We can control which category should be omitted and also specify that all dummy variables should be generated (see `help xi`). But the main use of `xi` is as a prefix, if we want to include a large set of dummy variables or dummy variables and interactions with dummy variables, we can use `xi` to save us the work of defining every variable by itself. And we can easily drop the variables after we used them with `drop _*`.

```
. xi: sum i.country*year
i.country      _Icountry_1-6      (_Icountry_1 for country==Canada omitted)
i.country*year  _IcouXyear_#      (coded as above)
```

Variable	Obs	Mean	Std. Dev.	Min	Max
--- -----	---	---	---	---	---
_Icountry_2	66	.1666667	.3755338	0	1
_Icountry_3	66	.1666667	.3755338	0	1
_Icountry_4	66	.1666667	.3755338	0	1
_Icountry_5	66	.1666667	.3755338	0	1
_Icountry_6	66	.1666667	.3755338	0	1
--- -----	---	---	---	---	---
year	65	1933.846	347.2559	0	2000
_IcouXyear_2	65	307	725.5827	0	2000
_IcouXyear_3	65	307	725.5827	0	2000
_IcouXyear_4	65	337.6154	753.859	0	2000
_IcouXyear_5	65	337.6154	753.859	0	2000
--- -----	---	---	---	---	---
_IcouXyear_6	65	337.6154	753.859	0	2000

Lags and leads

To generate lagged population in the G7 dataset:

```
. so countrycode year  
  
. by countrycode: gen lagpop=pop[_n-1] if year==year[_n-1]+1
```

Processing the statement country-by-country is necessary to prevent data from one country being used as a lag for another, as could happen with the following data:

country	Year	pop
AUS	1996	18312
AUS	1997	18532
AUS	1998	18751
AUT	1950	6928
AUT	1951	6938
AUT	1952	6938

The `if` argument avoids problems when there isn't a full panel of years – if the dataset only has observations for 1950, 1955, 1960-1998, then lags will only be created for 1961 on. A lead can be created in similar fashion:

```
. so country year  
. by country: gen leadpop=pop[_n+1] if year==year[_n+1]-1
```

Cleaning the data

This section covers a few techniques that can be used to fill in gaps in your data.

Fillin and expand

Suppose you start with a dataset that has observations for some years for one country, and a different set of years for another country:

country	Year	pop
AGO	1960	4816
AGO	1961	4884
ARG	1961	20996
ARG	1962	21342

You can “rectangularize” this dataset as follows:

```
. fillin country year
```

This creates new missing observations wherever a `country-year` combination did not previously exist:

country	Year	pop
AGO	1960	4816
AGO	1961	4884
AGO	1962	.
ARG	1960	.
ARG	1961	20996
ARG	1962	21342

It also creates a variable `_fillin` that shows the results of the operation; 0 signifies an existing observation, and 1 a new one.

If no country had data for 1961, then the `fillin` command would create a dataset like:

country	Year	pop
AGO	1960	4816
AGO	1962	.
ARG	1960	.
ARG	1962	21342

So, to get a proper “rectangle”, you would first have to ensure that at least one observation for the year 1961 exists:

```
. expand 2 if _n==1
. replace year=1961 if _n==_N
. replace pop=. if _n==_N
```

`expand 2` creates 2 observations identical to observation number one (`_n==1`) and places the additional observation at the end of the dataset, i.e. observation number `_N`. As well as recoding the year in this additional observation, it is imperative to replace all other data with missing values – the original dataset has no data for 1961, so the expanded dataset should have missings for 1961. After this has been done, you can now apply the `fillin` command to get a complete “rectangle”.

These operations may be useful if you want to estimate missing values by, for example, extrapolation. Or if you want to replace all missing values with zero or some other amount.

Interpolation and extrapolation

Suppose your population time-series is incomplete – as with some of the countries in the PWT (e.g. `STP` which is Sao Tome and Principe). You can linearly interpolate missing values using:

```
. so country
. by country: ipolate pop year, gen(ipop)
```

country	Year	pop
STP	1995	132
STP	1996	135.29
STP	1997	.
STP	1998	141.7
STP	1999	144.9
STP	2000	148

Note, first of all, that you need to interpolate by country, otherwise Stata will simply interpolate the entire list of observations irrespective of whether some observations are for one country and some for another. The first variable listed after the `ipolate` command is the variable you actually want to interpolate, the second is the dimension along which you want to interpolate. So, if you believe population varies with time, you can interpolate along the time dimension. You then need to specify a name for a new variable that will contain all the original and interpolated values – here `ipop`. You can use this cleaned-up version in its entirety in subsequent analysis, or you can select values from it to update the original variable, e.g. to clean values for `STP` only:

```
. replace pop=ipop if country=="STP"
```

Linear extrapolation can be achieved with the same command, adding the `epolate` option, e.g. to extrapolate beyond 2000:

```
. so country
. by country: ipolate pop year, gen(ipop) epolate
```

Note, however, that Stata will fail to interpolate or extrapolate if there are no missing values to start with. No 2001 or 2002 observations actually exist, so Stata will not actually be able to extrapolate beyond 2000. To overcome this, you will first have to create blank observations for 2001 and 2002 using `expand` (alternatively, if these observations exist for other countries, you can rectangularise the dataset using `fillin`).

Splicing data from an additional source

It is also possible to fill gaps with data from another source, as long as the series from both sources are compatible. For example, one source may provide data for 1950-92 and another for 1970-2000 with data for the overlapping years being identical. In such cases, you can simply replace the missing years from one source with the complete years from the other.

It is more common, however, for the data in the overlapping years to be similar but not identical, as different sources will often use different methodologies and definitions. In such instances, you can splice the data from one source on to that from the other. For example, the latest version of PWT has data for the unified Germany going back to 1970 while the earlier PWT5.6 has data for West Germany going all the way back to 1950. It is arguably reasonable to assume that the trends in the total German data were similar to those in the West German data and to splice the early series onto the up-to-date version. To do this, you must first merge the old series into the new one, making sure to rename the variables first, e.g. rename `pop` in PWT6.1 to `pop61`, and to ensure that both Germany's are coded identically, e.g. `GER`.

```
. gen temp1=pop61/pop56 if country=="GER" & year==1970

. egen diff=mean(temp1), by(country)
. replace pop61=pop56*diff if pop61==. & year<1970
```

country	year	pop56	pop61	temp1	diff
GER	1968	59499			1.281248
GER	1969	60069			1.281248
GER	1970	60651	77709	1.281248	1.281248
GER	1971	61303	78345		1.281248
GER	1972	61675	78715		1.281248

Imputing missing values from the data

When neither interpolation nor adding information from other data sets seems to be feasible, it is also possible to impute data given the nonmissing information in the data set. Statisticians distinguish several forms of missing values. Broadly there are two categories, data missing (completely) at random – `M(C)AR` – and data with non-ignorable missings.

The former can be solved most easily with Stata's `impute` command. This command basically runs a regression of the variable for which we want to impute missing values on a set of variables and uses the estimated coefficients and the information in the regressors to predict the missing values. This type is a form of conditional single imputation and relies on the assumption that missings are randomly assigned. An alternative is hot deck imputation which means simply drawing a value at random from the observed values of a variable with missings. Hot deck imputation is not standard in Stata but there is a user-written package (`hotdeck`) which solves that problem. Hot deck imputation also relies on the random assignment assumption of missing values.

If several variables have missing values or missings are not completely random, multiple imputation can be used. Multiple imputation (MI) works in three steps. First the missing values are imputed not once but several times (e.g. 10 times) and second the analysis is run on all imputed data sets and in the third step all results are aggregated. MI is implemented in Stata in the user-written programs `ice` and `mim` (how these can be installed is described in the post-estimation section). The MI algorithms implemented in Stata allow for imputation of missing values based on random draws from an estimated posterior distribution for the variables that exhibit missing values. The `ice` command allows very flexible specification of the prediction equations and for other methods to impute data as well. An example of how to use the commands is given on the UCLA webpage: <http://www.ats.ucla.edu/stat/stata/library/default.htm> and more information can be found at <http://multiple-imputation.com/>.

If data is not missing at random the situation is more tricky. We can use external information to make predictions (e.g. using census data on age in a district to predict the missing values in that district). But in general we will probably have to make a strong assumption on the type of nonrandomness in the missings. For information on this topic the work of Roderick J.A. Little can be a first starting point.

Panel Data Manipulation: Long versus Wide data sets

Reshape

Datasets may be laid out in wide or long formats. Suppose we keep population data for 1970-75 only:

```
. keep country country_code year pop
. keep if year<=1975
```

In **long** format, this looks like:

country	country_code	year	pop
Canada	CAN	1970	21324
Canada	CAN	1971	21962.1
Canada	CAN	1972	22219.6
Canada	CAN	1973	22493.8
Canada	CAN	1974	22808.4
Canada	CAN	1975	23142.3
France	FRA	1970	52040.8
France	FRA	1971	52531.8
France	FRA	1972	52993.1
France	FRA	1973	53420.5
France	FRA	1974	53771
France	FRA	1975	54016

And the same data in **wide** format looks like:

country	country_code	pop1970	pop1971	pop1972	pop1973	pop1974	pop1975
Canada	CAN	21324	21962.1	22219.6	22493.8	22808.4	23142.3
France	FRA	52040.8	52531.8	52993.1	53420.5	53771	54016
United Kingdom	GBR	55632	55928	56097	56223	56236	56226
Germany	GER	77709	78345	78715	78956	78979	78679
Italy	ITA	53821.9	54073.5	54381.3	54751.4	55110.9	55441
Japan	JPN	103720	104750	106180	108660	110160	111520
United States	USA	205089	207692	209924	211939	213898	215981

The vast majority of Stata commands work best when the data is in long format. In any case, to convert formats from long to wide:

```
. reshape wide pop, i(country_code) j(year)
```

or from wide to long:

```
. reshape long pop, i(country_code) j(year)
```

The variable(s) immediately behind `long` or `wide` is the one that contains the data we want to reshape (the “data variable”, in our case `pop`). Note that in the `reshape long` case, Stata will reshape all variables that start with the letters you put behind `long`. Here, there are actually six of them (`pop1970`-`pop1975`, all starting with `pop`). The `i()` specifies the variable(s) whose unique values denote a logical observation in wide format. In our case, this is `country`. It uniquely identifies every data entry in wide format (here: `pop`). The `j()` specifies the variable whose unique values denote a sub-observation, in our case `year`. That is, within every group of countries, `year` uniquely identifies observations. In long format, `i()` and `j()` together completely identify each observation.

If there are more than two indicator variables in wide format, then be careful to include the correct list in i(). For example, if there were also an agegroup indicator variable, so that pop actually referred to population in a given age group, then we could reshape the data from country / agegroup / year / pop to country / agegroup / pop1960 / pop1961 / etc using:

```
. reshape wide pop, i(country agegroup) j(year)
```

If there is more than one data variable, first drop the variables you are not interested in, and then make sure to include the full list you are interested in reshaping within the command:

```
. reshape wide pop cgdp pi, i(country) j(year)
```

This will create new variables pop1970-1975, cgdp1970-1975 and pi1970-1975. Note if you had not dropped all other variables beforehand, you would get an error message. For example, if you had forgotten to delete cc:

```
. cc not constant within country
. Type "reshape error" for a listing of the problem observations.
```

As Stata suggests, “reshape error” will list all observations for which country does not uniquely identify observations in wide format (here, these are actually all observations!). More generally, any variable that varies across both i() and j() variables either needs to be dropped before reshape wide or be included in the data variable list. Intuitively, Stata would not know where to put the data entries of such variables once year has gone as an identifier.

We could also have reshaped the original long data to have the country variable as wide:

```
. reshape wide pop, i(year) j(country) string
```

Note, you need to specify the string option when j() is a string variable. Browsing the resulting data:

year	popCAN	popFRA	popGBR	popGER	popITA	popJPN	popUSA
1970	21324	52040.8	55632	77709	53821.9	103720	205089
1971	21962.1	52531.8	55928	78345	54073.5	104750	207692
1972	22219.6	52993.1	56097	78715	54381.3	106180	209924
1973	22493.8	53420.5	56223	78956	54751.4	108660	211939
1974	22808.4	53771	56236	78979	55110.9	110160	213898
1975	23142.3	54016	56226	78679	55441	111520	215981

To create variables named CANpop / FRApop / GBRpop instead of popCAN/popFRA/popGBR, use:

```
. reshape wide @pop, i(year) j(country) string
```

The @ is useful when, for example, you start with a dataset that has the dimension you want to reshape written the “wrong” way around. It denotes where the suffix/prefix is affixed. Suppose you are given a dataset with country / youngpop / oldpop. You can reshape the pop variable to long to give country / agegroup / pop using:

```
. reshape long @pop, i(country) j(agegroup) string
```

Estimation

We now move on from the manipulation of databases to the more exciting material of running regressions. In this tutorial, we shall use data from Francesco Caselli's "Accounting for Cross-Country Income Differences" which is published in the Handbook of Economic Growth (2005, Ch. 9). There is a link to these data on my website. But before we start looking at the basics of regression commands, let us look at Stata's graph capabilities in more detail.

Descriptive graphs

Stata allows a large variety of graphs and options to customize them (see <http://www.ats.ucla.edu/stat/stata/topics/graphics.htm> for a more indepth overview). Here we will only consider some very basic graphs. We already introduced the `graph` command to plot a simple histogram and a scatter plot. We will extend these examples here and focus on formatting graphs via the `graph` options. A very useful command that helps us manage very long code in do-files is the `#delimit` command.

```
#delimit ;
```

or short

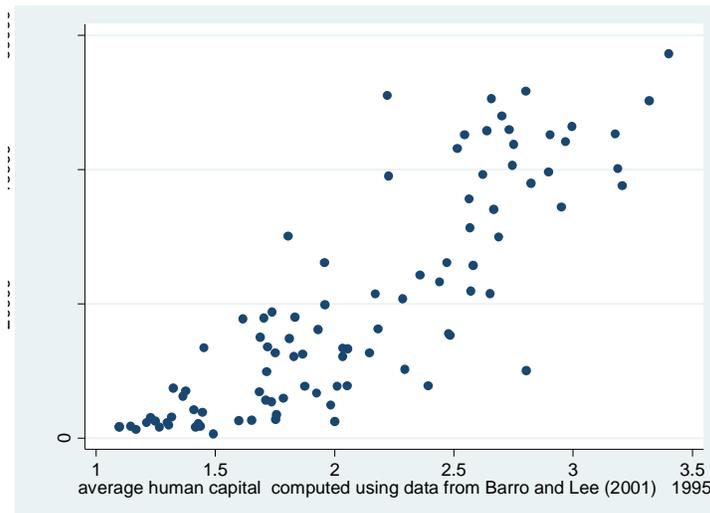
```
#d;
```

The `delimit` command changes what Stata perceives as the end of a command. Normally we write one command per line, that is the end of a line denotes the end of a command as well. `#delimit` introduces a character – the semicolon (;) – to denote the end of a command. This way we can either write several commands on one line, or (more importantly) use several lines for the same command. To revert back to the end of line as the end of a command we write:

```
#d cr
```

Let us start with a simple scatter plot, a command we have used already.

```
graph twoway scatter y h
```

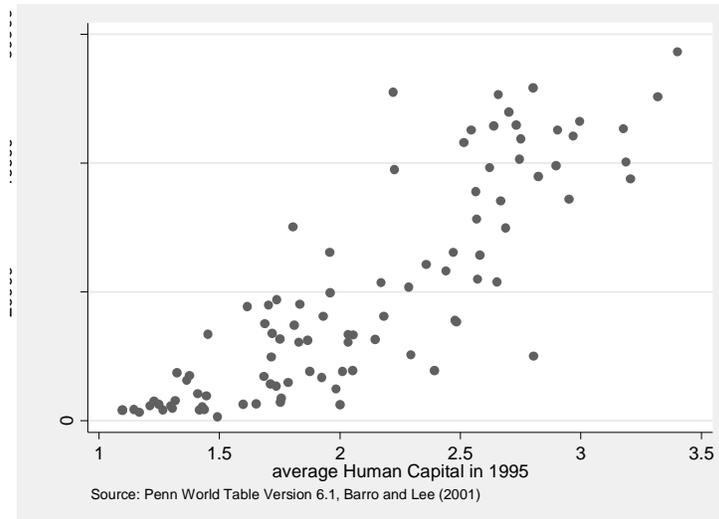


The graph depicts real per worker GDP on the vertical and average human capital on the horizontal axis, for all countries in the sample. We left the options all at standard and so we have a coloured graph with the variable labels as names for the axes. The `graph` command has some plots that do not fall into the `twoway` category, e.g. box-and-whiskers plots, but most of the plots you see in published articles are twoway-type of plots. The first thing we should change about this graph is the naming of the axes. We could either change the label of the underlying variables, or use the `graph` commands axis options. The second thing we want to change is that Stata produces a coloured graph. While colours are good for presentations, they will not appear in any paper.

```

#d;
graph twoway scatter y h,
    scheme(s2mono) ytitle("real GDP per worker")
    xtitle("average Human Capital in 1995")
    note("Source: Penn World Table Version 6.1, Barro and Lee (2001)");
#d cr

```

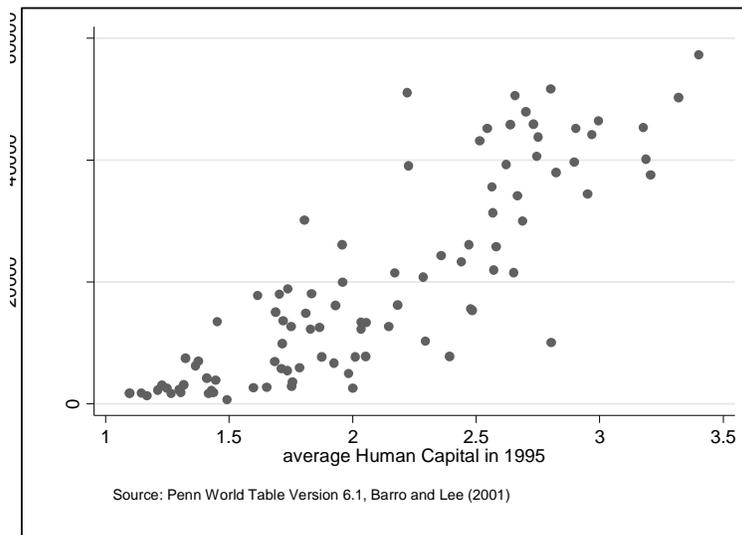


Stata has some inbuilt colour definitions (like the standard colour scheme of the first graph or this black-and-white scheme) which are available via the `scheme` option. The grey shading around the graph is not really a nice feature and so we will make some changes to the standard scheme we chose. Also the footnote about the source of the data could be a little further apart from the axis label. The title, axis names, the note field, etc. are

```

#d;
graph twoway scatter y h,
    scheme(s2mono) ytitle("real GDP per worker")
    xtitle("average Human Capital in 1995")
    note("Source: Penn World Table Version 6.1, Barro and Lee (2001)"
        , margin(medium))
    graphregion(fcolor(white) lpattern(solid) lcolor(black) lwidth(medium));
#d cr

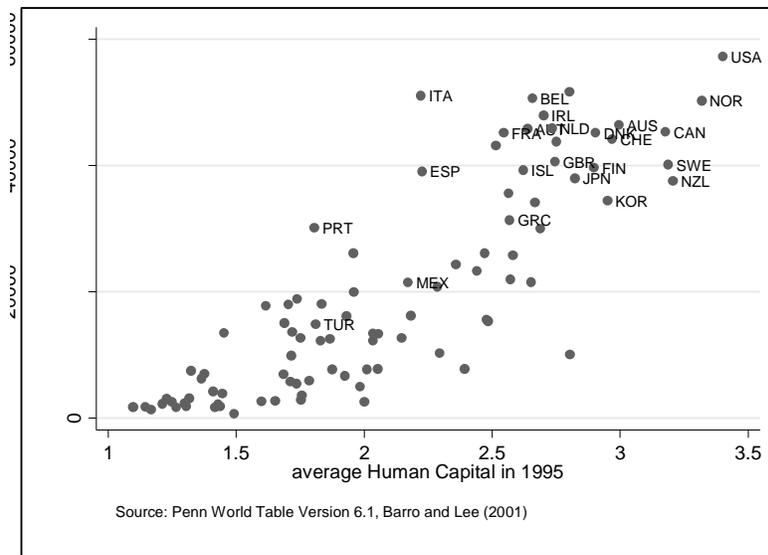
```



To give the reader a better idea of what is represented by the dots we could add labels to them. Given the number of observations this would probably be more confusing than helpful. So instead of putting a country name to each single point we could select

only a few. But how can we tell Stata to distinguish between two sets of points? We generate a dummy variable that indicates to which set an observation belongs and draw two scatter plots within one graph. One for each set. We are not limited to drawing only scatter plots in the same graph, we could for example overlay the scatter plot with the fitted line from a regression. Note that as with the “note” textbox in the previous example, each individual element of the command can have own options, in addition to the options that apply to the whole graph. To separate the plots within one graph we can either surround each plot command by parentheses – () – or use two bars – || –, both are fine. Note that the plots are drawn in the order that we use in the command, i.e. the first plot will be the backmost and each additional plot will be layered on top of it.

```
#d;
graph twoway
  (scatter y h if oecd != 1, mstyle(p1))
  (scatter y h if oecd == 1, mstyle(p1) mlabel(iso))
  , scheme(s2mono) ytitle("real GDP per worker")
  xtitle("average Human Capital in 1995")
  note("Source: Penn World Table Version 6.1, Barro and Lee (2001)"
    , margin(medium))
  graphregion(fcolor(white) lpattern(solid) lcolor(black) lwidth(medium))
  legend(off);
#d cr
```



We need to explicitly specify the style of the scatter markers since Stata chooses different markers for each plot by default, we also need a variable that specifies the label names for the markers. Also by default Stata adds a legend that normally tells the reader what the different plots/symbols/lines in a graph mean. But since we only use two plots as a trick to add labels we do not need a legend and suppress it with the `legend(off)` option.

How can we now save the graphs so we can use them in Word or Latex? The easiest (and probably worst way) is to copy the graphs directly into Word or Scientific Workplace. Note that you cannot do this if you use an editor other than Scientific Workplace (e.g. WinEdt, TeXnicCenter) for Latex documents. To do this simply select “Copy Graph” from the “Edit” menu of the graph window in Stata and paste into your program of choice.

The better choice is to export your graphs. Stata allows for different file types when you use the `graph export` function. Sadly not all of them are available under all types of operating systems. Under Windows I would recommend saving graphs as PNG files. PNG is a file format similar to GIF which was used a lot (and is sometimes still used) on internet websites. If you are using Word, PNG is the way to go. If you use Latex EPS is a good choice, but might give you trouble compiling your document (it is not possible to compile a document with EPS graphics directly to PDF but you have to compile a DVI file and then in turn make it into a PDF). EPS is a format that should be readable under all operating systems. So we finish our graph with:

```
graph save "H:\ECStata\MyFirstGraph", replace
graph export "H:\ECStata\MyFirstGraph.png", replace
```

Estimation syntax

Before we delve into some particular regression commands let us consider the syntax in Stata help for the details on estimation. The basic information is:

- There are many different models of estimation. The main commands include `regress`, `logit`, `logistic`, `sureg`.
- Most have a similar syntax:

```
command varlist [weight] [if exp] [in range] [, options]
```

- 1st variable in the varlist is the dependent variable, and the remaining are the independent variables.
- You can use Stata's syntax to specify the estimation sample; you do not have to make a special dataset.
- You can, at any time, review the last estimates by typing the estimation command without arguments.
- The `level()` option to indicate the width of the confidence interval. The default is `level(95)`.

Once you have carried out your estimation, there are a number of post-estimation commands that are useful:

- You can recall the estimates, VCM, standard errors, etc...;
- You can carry out hypothesis testing => `test` (Wald tests), `testnl` (non-linear Wald tests), `lrtest` (likelihood-ratio tests), `hausman` (Hausman's specification test);
- You can use Stata's `predict` command, which does predictions and residual calculations.

Weights and subsets

Most Stata commands allow the use of `weights` and the `if` and `in` qualifiers. `if` and `in` were discussed earlier and have the same use when applied to regression commands as with other commands. Instead of running the regression on all observations, the `if` and `in` qualifier limit the data to a certain subset.

```
. regress cgdp pop if year < 2000
```

This command runs an ordinary least squared (OLS) regression of per capita GDP on the population level for all years prior to 2000. What is important to note is that when we want to apply post-estimation commands, for example if we want to generate the residual for each observation, that we apply the same conditions as for the regression command. If we fail to control for the selection of a subset of the data we might inadvertently conduct an out-of-sample prediction.

What we haven't discussed yet is the use of weights in Stata. There are four types of weights in Stata.

Sampling weights `[pweight]` Sampling weights are the inverse sampling probability, that is how many subjects of the population are represented by the observation. This is a very common type of weight in micro data samples. Often certain firms of different sizes have different probabilities of being in a sample, ethnic groups are often oversampled in surveys, etc. The reason is that with a fixed sampling probability the number of observations for certain types of subjects in the population is too small to yield any statistically valid results, so oversampling is applied. Sampling weights allow the user to account for those different sampling probabilities.

Analytic weights `[aweight]` Analytic weights are appropriate when you run commands on aggregated data. We might want to run a regression of county level average wages on county characteristics. Analytical weights are then the number of individuals that are used to calculate the average wage. The reason is that the more observations are used to calculate the average wage the more precisely the population average wage is estimated and therefore the more we want to rely on that information. Analytic weights should not be used in lieu of sampling weights when Stata does not allow the use of sampling weights!

Frequency and importance weights These two types of weights are less frequently used. Frequency weights are used when memory is conserved by dropping observations that have exactly the same values in all variables. Importance weights are a programmers option and beyond the need of this course (See the [U] User's Guide for more detail).

For most day to day-to-day work `pweights` and `aweights` should suffice. If you use a complex survey you might need to go further and use the survey (`svy`) commands in Stata. These allow you account for stratified and clustered sampling as well as differing sampling probabilities.

Linear regression

Stata can do a lot of general and very specialized regression commands. With Stata 10 there are now three sets of specialized commands for time series data, panel data, survey data and survival data. Stata can do a lot of fancy regressions (and most of which we will not talk about in these classes). The syntax for most of them is very similar and so we will focus on few commands in detail rather than discuss the whole list. Just so that you know the main ones, here is an abbreviated list of other regression commands that may be of interest:

anova	analysis of variance and covariance
cnreg	censored-normal regression
heckman	Heckman selection model
intreg	interval regression
ivreg	instrumental variables (2SLS) regression
newey	regression with Newey-West standard errors
prais	Prais-Winsten, Cochrane-Orcutt, or Hildreth-Lu regression
qreg	quantile (including median) regression
reg	ordinary least squares regression
reg3	three-stage least squares regression
rreg	robust regression (NOT robust standard errors)
sureg	seemingly unrelated regression
svyheckman	Heckman selection model with survey data
svyintreg	interval regression with survey data
svyivreg	instrumental variables regression with survey data
svyregress	linear regression with survey data
tobit	tobit regression
treatreg	treatment effects model
truncreg	truncated regression
xtabond	Arellano-Bond linear, dynamic panel-data estimator
xtintreg	panel data interval regression models
xtreg	fixed- and random-effects linear models
xtregar	fixed- and random-effects linear models with an AR(1) disturbance
xttobit	panel data tobit models

We will focus on this is the most basic form of linear regression. `regress` fits a model of `depvar` on `varlist` using linear regression. The `help regress` command will bring up the following instructions for using `regress`.

```
regress depvar [varlist] [if exp] [in range] [weight] [, level(#) beta vce(robust/cluster(varname)/bootstrap/jackknife/hc2/hc3) hascons noconstant tsscons noheader eform(string) depname(varname) mse1 plus ]
```

Looking in the bottom of this help file will explain the options as follows:

Options

level(#) specifies the confidence level, in %, for confidence intervals of the coefficients; see help level.

beta requests that normalized beta coefficients be reported instead of confidence intervals. `beta` may not be specified with `cluster()`.

vce(robust) specifies that the Huber/White/sandwich estimator of variance is to be used in place of the traditional calculation. See [U] 20.15 Obtaining robust variance estimates.

vce(hc2) and **vce(hc3)** specify an alternative bias correction for the robust variance calculation. `hc2` and `hc3` may not be specified with `cluster()`. `hc2` uses $u_j^2/(1-h_j)$ as the observation's variance estimate. `hc3` uses $u_j^2/(1-h_j)^2$ as the observation's variance estimate. Specifying either `hc2` or `hc3` implies `robust`.

vce(cluster(varname)) specifies that the observations are independent across groups (clusters) but not necessarily independent within groups. `varname` specifies to which group each observation belongs; e.g., `cluster(personid)` in data with repeated observations on individuals. `cluster()` can be used with `pweights` to produce estimates for unstratified cluster-sampled data, but see help `svyregress` for a command especially designed for survey data. Specifying `cluster()` implies `robust`.

vce(bootstrap) and **vce(jackknife)** specify that the variance is estimated by resampling the data. The bootstrap resamples from the data with replacement while the jackknife consecutively deletes one observation. With both options the estimator is calculated several times which might take very long.

hascons indicates that a user-defined constant or its equivalent is specified among the independent variables. Some caution is recommended when using this option as resulting estimates may not be as accurate as they otherwise would be. Use of this option requires "sweeping" the constant last, so the moment matrix must be accumulated in absolute rather than deviation form. This option may be safely specified when the means of the dependent and independent variables are all "reasonable" and there are not large amounts of colinearity between the independent variables. The best procedure is to view hascons as a reporting option -- estimate with and without hascons and verify that the coefficients and standard errors of the variables not affected by the identity of the constant are unchanged. If you do not understand this warning, it is best to avoid this option.

noconstant suppresses the constant term (intercept) in the regression.

tsscons forces the total sum of squares to be computed as though the model has a constant; i.e., as deviations from the mean of the dependent variable. This is a rarely used option that has an effect only when specified with nocons. It affects only the total sum of squares and all results derived from the total sum of squares.

noheader, **eform()**, **depname()**, **mse1**, and **plus** are for ado-file (i.e. self-written commands) writers; see [R] regress.

As described above, most estimation commands will follow this type of syntax but the available options will differ and so you should check the relevant help files if you wish to use these approaches. Of course, Stata has a number of defaults and so you don't need to include any options if you don't wish to change the default (though it is always good to figure out what the default is!)

Lets start with a very simple regression of GDP per worker (y) on capital-output ratio (k).

```
. regress y k
```

Source	SS	df	MS			
Model	2.5465e+10	1	2.5465e+10	Number of obs =	104	
Residual	2.3380e+09	102	22921482.3	F(1, 102) =	1110.99	
Total	2.7803e+10	103	269936187	Prob > F =	0.0000	
				R-squared =	0.9159	
				Adj R-squared =	0.9151	
				Root MSE =	4787.6	

	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
y						
k	.3319374	.0099587	33.33	0.000	.3121844	.3516904
_cons	4720.016	617.1018	7.65	0.000	3495.998	5944.035

There are a few points to note here:

- The first variable listed after the `regress` (or `reg` for short) command is the dependent variable, and all subsequently listed variables are the independent variables.
- Stata automatically adds the constant term or intercept to the list of independent variables (use the `noconstant` option if you want to exclude it).
- The top-left corner gives the ANOVA decomposition of the sum of squares in the dependent variable (Total) into the explained (Model) and unexplained (Residual).
- The top-right corner reports the statistical significance results for the model as a whole.
- The bottom section gives the results for the individual explanatory variables.

The `regress` command can be used with the `robust` option for estimating the standard errors using the Huber-White sandwich estimator (to correct the standard errors for heteroscedasticity):

```
. regress y k, robust
```

Regression with robust standard errors	Number of obs =	104
	F(1, 102) =	702.15
	Prob > F =	0.0000
	R-squared =	0.9159
	Root MSE =	4787.6

	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
k	.3319374	.0125268	26.50	0.000	.3070905	.3567842
_cons	4720.016	506.2807	9.32	0.000	3715.811	5724.222

The coefficient estimates are exactly the same as in straightforward OLS, but the standard errors take into account heteroscedasticity. Note, the ANOVA table is deliberately suppressed as it is no longer appropriate in a statistical sense.

Sometimes you also want to allow for more general deviations from the iid-assumption on the error term. The option `cluster(group)` allows for arbitrary correlation within specified groups (see Wooldridge, “Econometrics of Cross-Section and Panel Data”, chapter 4, for more details and limitations of this approach). For example, you might think that in a panel of countries, errors are correlated across time but independent across countries. Then, you should cluster standard errors on countries. In our example, we do not have a time dimension so clustering on country yields the same results as the robust option (which is a special case of the cluster option):

```
. regress y k, cluster(country)
```

Stata comes with a large amount of regression diagnostic tools, such as tests for outliers, heteroskedasticity in the errors etc. A good survey is available at <http://www.ats.ucla.edu/stat/stata/webbooks/reg/chapter2/statareg2.htm>. We will focus on two useful tools for detecting influential observations and looking at partial correlations. The first tool is the command `lvr2plot` (read leverage-versus-residual squared plot). This is not available after the *robust* option is used so let us revert back to the original regression:

```
. regress y k
. lvr2plot, mlabel(country)
```

This plots the leverages of all observations against their squared residuals (the option `mlabel` labels points according to the variable listed in brackets behind it). Leverage tells you how large the influence of a single observation on the estimated coefficients is. Observations with high values could potentially be driving the results obtained (especially if they also have a large squared residual) so we should check whether excluding them changes anything.

The second command is `avplot` (added-variable plot) which graphs the partial correlation between a specified regressor and the dependent variable. For this not to be simply the fitted values, we should add another variable such as human capital (*h*). Formally

```
. regress y k
. avplot k, mlabel(country)
```

For some very basic econometrics which also comes with the necessary Stata commands, see <http://psc.maths.lancs.ac.uk/shortCourses/notes/stata/session5.pdf> for model diagnostics.

Now you should play around with the regressions by adding constants, dropping variables from the regression.

Post-estimation

Once you have done your regression, you usually want to carry out some extra analysis such as forecasting or hypothesis testing. Here is a list of the most useful post-estimation commands:

Command	Description
adjust	Tables of adjusted means and proportions
estimates	Store, replay, display, ... estimation results
hausman	Hausman's specification test after model fitting
lincom	Obtain linear combinations of coefficients
linktest	Specification link test for single-equation models
lrtest	Likelihood-ratio test after model fitting
mfx	Marginal effects or elasticities after estimation
nlcom	Nonlinear combinations of estimators
predict	Obtain predictions, residuals, etc. after estimation
predictnl	Nonlinear predictions after estimation
suest	Perform seemingly unrelated estimation
test	Test linear hypotheses after estimation
testnl	Test nonlinear hypotheses after estimation
vce	Display covariance matrix of the estimators

Prediction

A number of predicted values can be obtained after all estimation commands, such as `reg`, `cnsreg`, `logit` or `probit`. The most important are the predicted values for the dependent variable and the predicted residuals. For example, suppose we run the basic regression again:

```
. regress y k h
. predict y_hat          /* predicted values for dependent var */
. predict r, residual    /* predicted residuals */
```

Stata creates new variables containing the predicted values, and these variables can then be used in any other Stata command, e.g. you can graph a histogram of the residuals to check for normality.

If we run a selected regression (e.g. just using OECD countries) and then wish to know how well this regression fits, we could run the following commands:

```
regress y k h          if oecd==1
predict y_hat_oecd    if oecd==1
predict r_oecd        if oecd==1, residual
```

The `if` statements are only necessary if you are running the analysis on a subset of dataset currently loaded into Stata. If you want to make out-of-sample predictions, just drop the `if` statements in the `predict` commands.

```
predict y_hat_oecd_full
predict r_oecd_full, residual
```

Hypothesis testing

The results of each estimation automatically include for each independent variable a two-sided t-test (for linear regressions) and a z-test (for regressions such as `logit` or `probit`) on the null hypothesis that the “true” coefficient is equal to zero. You can also perform an F-test or χ^2 test on this hypothesis using the `test` command:

```
. regress y k h y1985 ya
. test y1985 /*since Stata defaults to comparing the listed terms to zero, you can
simply use the variable*/

( 1)  y1985 = 0
      F( 1,    63) =    15.80
      Prob > F =    0.0002
```

The F-statistic with 1 numerator and 63 denominator degrees of freedom is 15.80. The p -value or significance level of the test is basically zero (up to 4 digits at least), so we can reject the null hypothesis even at the 1% level – y_{1985} is significantly different from zero. Notice that, since the critical values of the F -distribution and the F -statistic with 1 numerator degree of freedom is identical to the square of the same values from the t -distribution, so the F-test result is the same as the result of the t -test. Also the p -values associated with each test agree.

You can perform any test on linear hypotheses about the coefficients, such as:

```
. test y1985=0.5          /* test coefficient on y1985 equals 0.5 */
. test y1985 h          /* test coefficients on y1985 & h jointly zero */
. test y1985+h=-0.5     /* test coefficients on y1985 & h sum to -0.5 */
. test y1985=h          /* test coefficients on y1985 & h are the same */
```

With many Stata commands, you can refer to a list of variables using a hyphen, e.g. `desc k- ya` gives descriptive statistics on `exp, ya` and every other variable on the list between them. However, the `test` command interprets the hyphen as a minus, and gets confused because it thinks you are typing a formula for it to test. If you want to test a long list of variables, you can use the `testparm` command (but remember to use the `order` command to bring the variables in the right order first)

```
. order k h y1985 ya
. testparm k-ya

( 1)  k = 0
( 2)  h = 0
( 3)  y1985 = 0
( 4)  ya = 0

      F( 4,      63) =  370.75
      Prob > F =    0.0000
```

Extracting results

We have already seen how the `predict` command can be used to extract predicted values from Stata's internal memory for use in subsequent analyses. Using the `generate` command, we can also extract other results following a regression, such as estimated coefficients and standard errors:

```
regress y k h y1985 ya, robust
gen b_cons=_b[_cons]      /* beta coefficient on constant term */
gen b_k=_b[k]             /* beta coefficient on GDP60 variable */
gen se_k=_se[k]          /* standard error */
```

You can `tabulate` the new variables to confirm that they do indeed contain the results of the regression. You can then use these new variables in subsequent Stata commands, e.g. to create a variable containing t-statistics:

```
. gen t_k=b_k/se_k
```

or, more directly:

```
. gen t_k=_b[k]/_se[k]
```

Stata stores extra results from estimation commands in `e()`, and you can see a list of what exactly is stored using the `ereturn list` command:

```
. regress y k h y1985 ya, robust
. ereturn list

scalars:
      e(N) = 68
      e(df_m) = 4
      e(df_r) = 63
      e(F) = 273.7198124833108
      e(r2) = .9592493796249692
      e(rmse) = 3451.985251440704
      e(mss) = 17671593578.3502
      e(rss) = 750720737.0983406
      e(r2_a) = .9566620386487768
      e(ll) = -647.8670640006279
      e(ll_0) = -756.6767273270843
```

```
macros:
      e(depvar) : "y"
      e(cmd) : "regress"
      e(predict) : "regres_p"
      e(model) : "ols"
      e(vcetype) : "Robust"
```

```
matrices:
      e(b) : 1 x 5
      e(V) : 5 x 5
```

```
functions:
      e(sample)
```

`e(sample)` is a temporary variable that is 1 if an observation was used by the last regression command run and 0 otherwise. It is a useful tool to have. Earlier we ran the following commands:

```
regress y k h if oecd==1
predict y_hat_oecd if oecd==1
```

but in the event that the “if” statement is complex, we may wish to simply tell Stata to predict using the same sample it used in the regression. We can do this using the `e(sample)`:

```
predict y_hat_oecd if e(sample)
```

`e(N)` stores the number of observations, `e(df_m)` the model degrees of freedom, `e(df_r)` the residual degrees of freedom, `e(F)` the F-statistic, and so on. You can extract any of these into a new variable:

```
. gen residualdf=e(df_r)
```

And you can then use this variable as usual, e.g. to generate p-values:

```
. gen p_k=tprob(residualdf,t_k)
```

The `tprob` function uses the two-tailed cumulative Student's t-distribution. The first argument in parenthesis is the relevant degrees of freedom, the second is the t-statistic.

In fact, most Stata commands – not just estimation commands – store results in internal memory, ready for possible extraction. Generally, the results from other commands – that is commands that are not estimation commands – are stored in `r()`. You can see a list of what exactly is stored using the `return list` command, and you can extract any you wish into new variables:

```
. sum y
```

Variable	Obs	Mean	Std. Dev.	Min	Max
-----+-----					
y	105	18103.09	16354.09	630.1393	57259.25

```
. return list
```

scalars:

```
      r(N) = 105
r(sum_w) = 105
r(mean) = 18103.08932466053
r(Var) = 267456251.2136306
      r(sd) = 16354.08973968379
r(min) = 630.1392822265625
r(max) = 57259.25
r(sum) = 1900824.379089356
```

```
. gen mean_y=r(mean)
```

Note that the last command will give exactly the same results as `egen mean_y=mean(y)`.

OUTREG2 – the ultimate tool in Stata/Latex or Word friendliness?

There is a tool which will automatically create excel, word or latex tables or regression results and it will save you loads of time and effort. It formats the tables to a journal standard and was originally just for word (`outreg`) but now the updated version will also do tables for latex also.

There are other user-written commands that might be helpful, `outtable`, `outtex`, `estout`, `mat2txt`, etc. just find the one that suit your purpose best.

However, it does not come as a standard tool and so before we can use it, we must learn how to install extra ado files (not to be confused with running our own do files).

Extra commands on the net

Looking for specific commands

If you are trying to perform an exotic econometric technique and cannot find any useful command in the Stata manuals, you may have to programme in the details yourself. However, before making such a rash move, you should be aware that, in addition to the huge list of commands available in the Stata package and listed in the Stata manuals, a number of researchers have created their own extra commands. These extra commands range from the aforementioned exotic econometric techniques to mini time-saving routines. For example, the command `outreg2`.

You need to first locate the relevant command and then install it into your copy of Stata. The command can be located by trying different searches, e.g. to search for a command that formats the layout of regression results, I might search for words like “format” or “table”:

```
. search format regression table

Keyword search

Keywords:  format regression table
Search:   (1) Official help files, FAQs, Examples, SJs, and STBs

Search of official help files, FAQs, Examples, SJs, and STBs

FAQ      Can I make regression tables that look like those in journal articles?
. . . . . UCLA Academic Technology Services
5/01     http://www.ats.ucla.edu/stat/stata/faq/outreg.htm

STB-59   sg97.3 . . . . . Update to formatting regression output
(help outreg if installed) . . . . . J. L. Gallup
1/01     p.23; STB Reprints Vol 10, p.143
small bug fixes

STB-58   sg97.2 . . . . . Update to formatting regression output
(help outreg if installed) . . . . . J. L. Gallup
11/00    pp.9--13; STB Reprints Vol 10, pp.137--143
update allowing user-specified statistics and notes, 10%
asterisks, table and column titles, scientific notation for
coefficient estimates, and reporting of confidence interval
and marginal effects

STB-49   sg97.1 . . . . . Revision of outreg
(help outreg if installed) . . . . . J. L. Gallup
5/99     p.23; STB Reprints Vol 9, pp.170--171
updated for Stata 6 and improved

STB-46   sg97 . . . . . Formatting regression output for published tables
(help outreg if installed) . . . . . J. L. Gallup
11/98    pp.28--30; STB Reprints Vol 8, pp.200--202
takes output from any estimation command and formats it as
in journal articles

(end of search)
```

You can read the FAQ by clicking on the blue hyperlink. This gives some information on the command. You can install the command by first clicking on the blue command name (here `sg97.3`, the most up-to-date version) and, when the pop-up window appears, clicking on the install hyperlink. Once installed, you can create your table and then use the command `outreg2` as any other command in Stata. The help file will tell you the syntax.

However, I mentioned `outreg2` and this has not appeared here, so I may need to update more.

Checking for updates in general

New Stata routines and commands appear all the time and existing ones get updates. A simple way to keep up-to-date with any changes is to use the update commands. The first step is to check when your version was last updated:

```
. update
```

```
Stata executable
  folder:          \\st-server5\stata10$\
  name of file:    wsestata.exe
  currently installed: 11 Aug 2008

Ado-file updates
  folder:          \\st-server5\stata10$\ado\updates\
  names of files:  (various)
  currently installed: 22 Sep 2008

Utilities updates
  folder:          \\st-server5\stata10$\utilities
  names of files:  (various)
  currently installed: 27 May 2008

Recommendation
  Type -update query- to compare these dates with what is available from
  http://www.stata.com.
```

Stata consists of basically two sets of files, the executable file and the ado-files (the utilities are new and so far include only one program that is called internally by Stata). The former is the main programme while the latter present the different Stata commands and routines. In order to check whether there are any more up-to-date versions use the update query command:

```
. update query
(contacting http://www.stata.com)
```

```
Stata executable
  folder:          \\st-server5\stata10$\
  name of file:    wsestata.exe
  currently installed: 11 Aug 2008
  latest available: 11 Aug 2008

Ado-file updates
  folder:          \\st-server5\stata10$\ado\updates\
  names of files:  (various)
  currently installed: 22 Sep 2008
  latest available: 22 Sep 2008

Utilities updates
  folder:          \\st-server5\stata10$\utilities
  names of files:  (various)
  currently installed: 27 May 2008
  latest available: 27 May 2008

Recommendation
  Do nothing; all files up to date.
```

It looks like my executable and ado files are okay. If I needed to update my ado files, Stata would have told me to type update ado which would lead to the following type of update:

```
. update ado
(contacting http://www.stata.com)
```

```
Ado-file update log
  1. verifying \\st-server5\stata10$\ado\updates\ is writeable
  2. obtaining list of files to be updated
  3. downloading relevant files to temporary area
downloading checksum.hlp
```

```
...
downloading varirf_ograph.ado
downloading whatsnew.hlp
  4.  examining files
  5.  installing files
  6.  setting last date updated
```

Updates successfully installed.

Recommendation

See help whatsnew to learn about the new features

Finally, to learn about the new features installed, simply type help whatsnew.

But we know that outreg2 exists so how do we find it to install? Well, type outreg2 into google to convince yourself that it exists. Then type:

```
search outreg2, net
```

Web resources from Stata and other users

(contacting <http://www.stata.com>)

1 package found (Stata Journal and STB listed first)

```
-----
outreg2 from http://fmwww.bc.edu/RePEc/bocode/o
'OUTREG2': module to arrange regression outputs into an illustrative table
/ outreg2 provides a fast and easy way to produce an illustrative / table
of regression outputs. The regression outputs are produced / piecemeal and
are difficult to compare without some type of / rearrangement. outreg2
```

(click here to return to the previous screen)

(end of search)

Click on the blue link and follow instructions to install the ado file and help.

Most additional commands that you will find are available from the Statistical Software Archive (SSC) and can be installed by typing `ssc install` followed by the name of the command. If the command you want to install is not available from SSC but elsewhere on the internet you can use the `net install` command. But you should be wary of the source of the commands you install and always test them before starting to use them.

```
. ssc install outreg2
checking outreg2 consistency and verifying not already installed...
installing into c:\ado\plus\...
installation complete.
```

Now using the help, try to figure out the syntax and then run the regressions from earlier in your do file but create a table which places the results of, for example, 6 regressions next to each other in either word or latex.

Problems when installing additional commands on shared PCs

When you are not using your private PC or Laptop but a shared PC, for example in the library, you might run into problems updating Stata or installing additional commands.

```
. ssc install outreg2
checking outreg2 consistency and verifying not already installed...
installing into c:\ado\plus\...
could not rename c:\ado\plus\next.trk to c:\ado\plus\stata.trk
could not rename c:\ado\plus\backup.trk to c:\ado\plus\stata.trk
r(699);
```

This error occurs when someone else installed additional commands for Stata on this PC before. The reason is simply that

Windows allows only the “owner” and administrators to change a file. To keep track of installed commands, Stata has to change some files. If you were not the first person to install additional commands (or update) on the PC you are using, these tracking files will belong to someone else and you cannot change them.

But there is no reason for despair as there are several workarounds for this problem. The first solution is not to install the command but to run the ado file so the command becomes available temporarily. When you install a command it will remain available even if you restart Stata. If on the other hand you only run the associated ado file, the command will only work until you exit the current Stata session.

```
. cap run http://fmwww.bc.edu/repec/bocode/o/outreg2.ado
```

When typing in the commands interactively the `capture` command is not necessary, but if you include the line as part of your do-file you should use it, since you will get an error message when you try to load the command into memory when you have already done so. The advantage of this method is that you will have to explicitly load all the commands you need into memory and so even if you change the PC you use often your do-files will still work. The disadvantage is that you will need internet access and that the help for the commands is not installed and cannot be accessed from Stata directly by typing `help outreg2`. You can however access the help for the command via the web repository.

```
. view http://fmwww.bc.edu/repec/bocode/o/outreg2.hlp
```

The other method to solve the renaming problem is to change the path where you install updates and additional commands. For additional commands this is the “Plus” path. You can check the current path with the `sysdir` command and change it by typing `sysdir set PLUS "H:\mypath"`.

```
. sysdir
STATA:  \\st-server5\stata10$\
UPDATES:  \\st-server5\stata10$\ado\updates\
BASE:  \\st-server5\stata10$\ado\base\
SITE:  \\st-server5\stata10$\ado\site\
PLUS:  c:\ado\plus\
PERSONAL:  c:\ado\personal\
OLDPLACE:  c:\ado\
```

```
. sysdir set PLUS "H:\ECStata"
```

```
. sysdir
STATA:  \\st-server5\stata10$\
UPDATES:  \\st-server5\stata10$\ado\updates\
BASE:  \\st-server5\stata10$\ado\base\
SITE:  \\st-server5\stata10$\ado\site\
PLUS:  H:\ECStata\
PERSONAL:  c:\ado\personal\
OLDPLACE:  c:\ado\
```

Exporting results “by hand”

While export commands that were written by other users might give you nice looking tables, they might not be versatile enough for your needs, or give you too much output, i.e. you might not be interested in all results, but just one number from several regressions.

What you can do in these cases is export information “by hand”, i.e. use Stata’s in-built functions to write information on the hard drive. The easiest way is to simply save a dataset containing the information you need. But that will not do you any good if you want to construct a table in Excel or LaTeX. What you can do is write an ASCII file that contains the numbers you want, and maybe some additional information.

```
. file open tmpHolder using "H:\ECStata\MyOutputFile.txt", write replace text
(note: file H:\ECStata\MyOutputFile.txt not found)
```

The `file` command handles the export to a text file. For this it uses a link to a file on the hard drive. The link has to be named (since we could in theory open several links at the same time) and will be referred to by its handle after being opened. The handle here is “tmpHolder”. In the options we specify that we want to open a file for writing, if the file already exists it should be

replaced and we want the output to be plain text. The file we use to save the results is specified after the `using` qualifier.

To write some text into the output file we write:

```
. file write tmpHolder "This is the header for my Output file" _n
```

Again we use the `file` command but now with `write` as subcommand. After the subcommand we specify which link should be used by providing a handle (here `tmpHolder`) and follow by the text we want to write into the text file. The `_n` is the newline command and so the next text will start in the second line of the output file. Now we don't want to export text only but more importantly numbers. Let us say the mean and the variance of a variable:

```
. sum y
```

Variable	Obs	Mean	Std. Dev.	Min	Max
y	105	18103.09	16354.09	630.1393	57259.25

```
. file write tmpHolder "y," (r(mean)) "," (r(Var)) _n
```

If we refer to some return values of descriptive or estimation commands we need to put them between parentheses, otherwise Stata will regard `r()` as text and just write the text and not the value of `r()` into the output file.

When we have finished writing lines into an output file we close it (i.e. sever the link) and save it by using the `close` subcommand.

```
. file close tmpHolder
```

More Estimation

There are a host of other estimation techniques which Stata can handle efficiently. Below is a brief look at a couple of these. Further information on these or any other technique you may be interested in can be obtained from the Stata manuals.

Constrained linear regression

Suppose the theory predicts that the coefficients for `REV` and `ASSASS` should be identical. We can estimate a regression model where we constrain the coefficients to be equal to each other. To do this, first define a constraint and then run the `cnsreg` command:

```
. constraint define 1 rev=assass /* constraint is given the number 1 */
. cnsreg gr6085 lgdp60 sec60 prim60 gcy rev assass pi60 if year==1990, constraint(1)
```

```
Constrained linear regression                                Number of obs =      100
                                                           F(   6,   93) =    12.60
                                                           Prob > F      =    0.0000
                                                           Root MSE     =    1.5025

( 1) - rev + assass = 0
```

gr6085	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lgdp60	-1.617205	.2840461	-5.69	0.000	-2.181264	-1.053146
sec60	.0429134	.0122297	3.49	0.001	.0184939	.0673329
prim60	.0352023	.007042	5.00	0.000	.0212183	.0491864
gcy	-.0231969	.017786	-1.30	0.195	-.0585165	.0121226
rev	-.2335536	.2877334	-0.81	0.419	-.804935	.3378279
assass	-.2335536	.2877334	-0.81	0.419	-.804935	.3378279
pi60	-.0054616	.0024692	-2.21	0.029	-.0103649	-.0005584
_cons	12.0264	2.073177	5.80	0.000	7.909484	16.14332

Notice that the coefficients for `REV` and `ASSASS` are now identical, along with their standard errors, t-stats, etc. We can define and apply several constraints at once, e.g. constrain the `LGDP60` coefficient to equal `-1.5`:

```
. constraint define 2 lgdp60=-1.5
. cnsreg gr6085 lgdp60 sec60 prim60 gcy rev assass pi60 if year==1990, constraint(1 2)
```

Dichotomous dependent variable

When the dependent variable is dichotomous (zero/one), you can run a Linear Probability Model using the `regress` command. You may also want to run a `logit` or a `probit` regression. The difference between these three models is the assumption that you make about the probability distribution of the latent dependent variable (LPM assumes an identity function, Logit a logistic distribution function, and Probit a normal distribution function).

For the sake of trying out these commands, let us “explain” why a country is an OECD member using a logit regressions:

```
. logit OECD lrgdpl if year==1990
```

```
Iteration 0:  log likelihood = -63.180951
...
Iteration 7:  log likelihood = -21.99139
```

```
Logit estimates                                Number of obs =      135
                                                LR chi2(1)      =      82.38
                                                Prob > chi2     =      0.0000
Log likelihood = -21.99139                    Pseudo R2      =      0.6519
```

OECD	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
lrgdpl	4.94118	1.119976	4.41	0.000	2.746067	7.136292
_cons	-47.38448	10.7335	-4.41	0.000	-68.42176	-26.3472

Panel Data

If you are lucky enough to have a panel dataset, you will have data on n countries/people/firms/etc, over t time periods, for a total of $n \times t$ observations. If t is the same for each country/person/firm then the panel is said to be balanced; but for most things Stata is capable of working out the optimal/maximum dataset available. There are a few things to note before using panel data commands:

1. Panel data should be kept in long form (with separate person and time variables). However, sometimes your data may be in wide form and needs to be converted to long form using the `reshape` command.
2. You have to declare your data a panel. One way to do this is using the `xtset` command (the previously used commands `iis` and `tss` are outdated as of Stata 10). To do this, you need two indicator variables, indicating the unit (`panelvar`) and time (`timevar`) dimensions of your panel. In our case, these are simply `year` and `country`. Note that panel dimensions cannot be string variables so you should first `encode` `country`. Once you have done this, use the `xtset` command:

```
. encode country, gen(country_no)
. xtset country_no year
```

You are now free to use Stata's panel data commands, although I will only make use of a few main ones (**bolded**):

xtdes	Describe pattern of xt data
xtsum	Summarize xt data
xttab	Tabulate xt data
xtdata	Faster specification searches with xt data
xtline	Line plots with xt data
xtreg	Fixed-, between- and random-effects, and population-averaged linear models
xtregar	Fixed- and random-effects linear models with an AR(1) disturbance
xtgls	Panel-data models using GLS
xtpcse	OLS or Prais-Winsten models with panel-corrected standard errors
xtcrhh	Hildreth-Houck random coefficients models
xtivreg	Instrumental variables and two-stage least squares for panel-data models
xtabond	Arellano-Bond linear, dynamic panel data estimator
xttobit	Random-effects tobit models
xtintreg	Random-effects interval data regression models
xtlogit	Fixed-effects, random-effects, & population-averaged logit models
xtprobit	Random-effects and population-averaged probit models
xtcloglog	Random-effects and population-averaged cloglog models
xtpoisson	Fixed-effects, random-effects, & population-averaged Poisson models
xtnbreg	Fixed-effects, random-effects, & population-averaged negative binomial models
xtgee	Population-averaged panel-data models using GEE

Describe pattern of xt data

`xtdes` is very useful to see if your panel is actually balanced or whether there is large variation in the number of years for which each cross-sectional unit is reporting.

```
. xtdes

country_no:  1, 2, ..., 168          n =          168
year:       1950, 1951, ..., 2000    T =           51
Delta(year) = 1; (2000-1950)+1 = 51
```


Tabulate xt data

xxtab is also a generalisation of the tabulate command for panel data and will show overall, within and between variation.

```
. xxtab G7
```

G7	Overall		Between		Within
	Freq.	Percent	Freq.	Percent	Percent
0	8211	95.83	161	95.83	100.00
1	357	4.17	7	4.17	100.00
Total	8568	100.00	168	100.00	100.00

(n = 168)

Panel regressions

xtreg is a generalisation of the regress commands. As with the summary data above, we can make use of the information in the cross-section (between) and also in the time-series (within). Also, as per your econometrics training, Stata allows you to run fixed-effects (fe), random effects (re) and between estimators using xtreg. More complicated estimation (such as the Arellano-Bond dynamic GMM estimator) have specific xt estimation commands.

Fixed Effects Regression

Fixed effects regression controls for unobserved, but constant, variation across the cross-sectional units. It is equivalent to including a dummy for each country/firm in our regression. Let us use the xtreg command with the fe option:

```
. xtreg grgdpch gdp60 openk kc kg ki, fe
```

```
Fixed-effects (within) regression      Number of obs      =      5067
Group variable (i): country_no        Number of groups   =      112

R-sq:  within = 0.0164                  Obs per group:  min =      2
      between = 0.2946                    avg   =      45.2
      overall  = 0.0306                    max   =      51

                                F(4, 4951)      =      20.58
corr(u_i, Xb) = -0.4277                Prob > F        =      0.0000
```

```
-----+-----
      grgdpch |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----+-----
      gdp60 | (dropped)
      openk |  -.0107672   .0042079    -2.56  0.011   - .0190166   - .0025178
      kc   |  -.0309774   .0089545    -3.46  0.001   - .0485322   - .0134225
      kg   |  -.0733306   .0147568    -4.97  0.000   - .1022604   - .0444007
      ki   |   .1274592   .0178551     7.14  0.000   .0924552    .1624631
      _cons |   4.425707   .7451246     5.94  0.000   2.964933    5.886482
-----+-----
      sigma_u |  1.6055981
      sigma_e |  6.4365409
      rho    |  .05858034   (fraction of variance due to u_i)
-----+-----
F test that all u_i=0:      F(111, 4951) =      1.82      Prob > F = 0.0000
```

Notice that gdp60, the log of GDP in 1960 for each country, is now dropped as it is constant across time for each country and so is subsumed by the country fixed-effect.

Between Effects

We can now use the xtreg command with the be option. This is equivalent to running a regression on the dataset of means by cross-sectional identifier. As this results in loss of information, between effects are not used much in practice.

```
. xtreg grgdpch gdp60 openk kc kg ki, be
```

```
Between regression (regression on group means)  Number of obs      =      5067
```

```

Group variable (i): country_no          Number of groups   =      112
R-sq:  within = 0.0100                  Obs per group: min =      2
      between = 0.4575                  avg =             45.2
      overall = 0.0370                  max =             51
sd(u_i + avg(e_i.))= 1.277099          F(5,106)           =      17.88
                                          Prob > F            =      0.0000

```

grgdpch	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
gdp60	-.5185608	.1776192	-2.92	0.004	-.8707083 - .1664134
openk	.0008808	.0029935	0.29	0.769	-.0050541 .0068156
kc	-.0151328	.009457	-1.60	0.113	-.0338822 .0036166
kg	-.0268036	.0149667	-1.79	0.076	-.0564765 .0028693
ki	.1419786	.0213923	6.64	0.000	.0995662 .184391
_cons	4.657591	1.587533	2.93	0.004	1.510153 7.80503

Random Effects

The command for a linear regression on panel data with random effects in Stata is `xtreg` with the `re` option. Stata's random-effects estimator is a weighted average of fixed and between effects.

```
. xtreg grgdpch gdp60 openk kc kg ki, re
```

```

Random-effects GLS regression          Number of obs   =      5067
Group variable (i): country_no        Number of groups =      112
R-sq:  within = 0.0143                Obs per group: min =      2
      between = 0.4235                avg =           45.2
      overall = 0.0389                max =           51
Random effects u_i ~ Gaussian          Wald chi2(5)    =      159.55
corr(u_i, X) = 0 (assumed)            Prob > chi2     =      0.0000

```

grgdpch	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
gdp60	-.5661554	.1555741	-3.64	0.000	-.8710751 - .2612356
openk	-.0012826	.0024141	-0.53	0.595	-.0060142 .003449
kc	-.0270849	.0061971	-4.37	0.000	-.039231 - .0149388
kg	-.0506839	.0101051	-5.02	0.000	-.0704895 - .0308783
ki	.1160396	.0127721	9.09	0.000	.0910067 .1410725
_cons	6.866742	1.239024	5.54	0.000	4.4383 9.295185
sigma_u	.73122048				
sigma_e	6.4365409				
rho	.01274156	(fraction of variance due to u_i)			

Choosing Between Fixed and Random Effects

Choosing between FE and RE models is usually done using a Hausman test, and this is easily completed in Stata using the `hausman` command. To run a Hausman test we need to run the RE and FE models and save the results using the `store` command. We then instruct Stata to retrieve the 2 sets of results and carry-out the test.

For example, using the same estimates as above, we can write the following in our do file:

```

xtreg grgdpch gdp60 openk kc kg ki, fe
estimates store fe
xtreg grgdpch gdp60 openk kc kg ki, re
estimates store re
hausman fe re

```

---- Coefficients ----				
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fe	re	Difference	S.E.
openk	-.0107672	-.0012826	-.0094846	.0034465
kc	-.0309774	-.0270849	-.0038924	.0064637
kg	-.0733306	-.0506839	-.0226467	.0107541
ki	.1274592	.1160396	.0114196	.0124771

b = consistent under Ho and Ha; obtained from xtreg
 B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(4) &= (b-B)'[(V_b-V_B)^{-1}](b-B) \\ &= 20.15 \\ \text{Prob}>\text{chi2} &= 0.0005 \end{aligned}$$

As described in the results, the null hypothesis is that there is no difference in the coefficients estimated by the efficient RE estimator and the consistent FE estimator. If there is no difference, then use the RE estimator – i.e. if the statistic is insignificant that is the Prob>chi2 is larger than .05 or .01. Otherwise, you should use FE, or one of the other solutions for unobserved heterogeneity as outlined in your Econometrics lectures.

Time series data

Stata has a very particular set of functions that control time series commands. But in order to use these commands, you must ensure that you tell Stata. Similar to the panel data commands above, we can do this using the `tsset`. For example:

```
tsset datevar
```

Once you have done this, you are free to use the time series commands – I present a selection of these below (type `help time` for the full list):

<code>tsset</code>	Declare a dataset to be time-series data
<code>tsfill</code>	Fill in missing times with missing observations in time-series data
<code>tsappend</code>	Add observations to a time-series dataset
<code>tsreport</code>	Report time-series aspects of a dataset or estimation sample
<code>arima</code>	Autoregressive integrated moving-average models
<code>arch</code>	Autoregressive conditional heteroskedasticity (ARCH) family of estimators
<code>tssmooth_ma</code>	Moving-average filter
<code>tssmooth_nl</code>	Nonlinear filter
<code>corrgram</code>	Tabulate and graph autocorrelations
<code>xcorr</code>	Cross-correlogram for bivariate time series
<code>dfuller</code>	Augmented Dickey-Fuller unit-root test
<code>pperron</code>	Phillips-Perron unit-roots test
<code>archlm</code>	Engle's LM test for the presence of autoregressive conditional heteroskedasticity
<code>var</code>	Vector autoregression models
<code>svar</code>	Structural vector autoregression models
<code>varbasic</code>	Fit a simple VAR and graph impulse-response functions
<code>vec</code>	Vector error-correction models
<code>varsoc</code>	Obtain lag-order selection statistics for VARs and VECMs
<code>varstable</code>	Check the stability condition of VAR or SVAR estimates
<code>vecrank</code>	Estimate the cointegrating rank using Johansen's framework
<code>irf create</code>	Obtain impulse-response functions and FEVDs
<code>vargranger</code>	Perform pairwise Granger causality tests after <code>var</code> or <code>svar</code>
<code>irf graph</code>	Graph impulse-response functions and FEVDs
<code>irf cgraph</code>	Combine graphs of impulse-response functions and FEVDs
<code>irf ograph</code>	Graph overlaid impulse-response functions and FEVDs

All of these can be implemented where appropriate by using the help function, manuals and internet resources (or colleagues know-how).

Stata Date and Time-series Variables

However, one of the issues with time series in Stata, and something that particularly challenges new users of Stata, is the data format used in the program. Therefore, I below provide some more advanced notes on this specialist topic.

The key thing is that there are 2 possible types of entry – date entries (which work in general for storing dates in Stata) and time-series entries (which are useful when we are not using daily data). Stata stores dates as the number of elapsed periods since January 1, 1960. When using a data-set that is not daily data, we want to use Stata's time-series function rather than the date function – the reason is that the dates for quarterly data will be about 3 months apart but the number of days between them will vary so telling Stata to go from Q1 to Q2 will involve changing the date from (for example) January 1st to April 1st – which is either 90 days or 91 days depending on whether it is a leap-year. Obviously our life would be easier if we could just tell Stata that one entry is Q1, and the other entry is Q2. For example, if we want to take first-differences between quarters, or even more trickily, if we wanted to take seasonal differences – Q1 minus Q1 from previous year.

Therefore when we have a variable that identifies the time-series elements of a dataset, we must tell Stata what type of data we are using – is it daily, weekly, monthly, quarterly, half-yearly or yearly. Therefore, if you use daily data it will be the number of

elapsed days since January 1st 1960 (which is therefore zero), but if you use quarterly data, it is the number of elapsed quarters since 1960 Q1. The following table explains the different formats:

Format	Description	Beginning	+1 Unit	+2 Units	+3 Units
%td	daily	01jan1960	02jan1960	03Jan1960	04Jan1960
%tw	weekly	week 1, 1960	week 2, 1960	week 3, 1960	week 4, 1960
%tm	monthly	Jan, 1960	Feb, 1960	Mar, 1960	Apr, 1960
%tq	quarterly	1st qtr, 1960	2nd qtr, 1960	3rd qtr, 1960	4th qtr, 1960
%th	half-yearly	1st half, 1960	2nd half, 1960	1st half, 1961	2nd half, 1961
%ty	yearly	1960	1961	1962	1963

Obviously, what you tell Stata here is highly important; we will see how to convert our data into Stata dates in a moment, but for now assume that we have a Stata date for January 1, 1999 – this is an elapsed date of 14245 (the number of days since January 1st 1960). If we were to use this number as different types of time-series data, then there would be very different outcomes as shown in the following table:

Daily	Weekly	Quarterly	Half-yearly	Yearly
%td	%tw	%tq	%th	%ty
01 Jan 1999	2233 W50	5521 Q2	9082 H2	-

These dates are so different because the elapsed date is actually the number of weeks, quarters, etc., from the first week, quarter, etc of 1960. The value for %ty is missing because it would be equal to the year 14,245 which is beyond what Stata can accept.

Therefore if we have a date format of 14245, but we want this to point to quarterly data, then we would need to convert it using special Stata functions. These functions translate from %td dates:

wofd(varname)	daily to weekly
moFd(varname)	daily to monthly
qofd(varname)	daily to quarterly
yofd(varname)	daily to yearly

Looking up in help can also show how to convert numbers between other formats (`help dates_and_times`).

Getting dates into Stata format

This section covers how we get an existing date or time variable into the Stata format for dates – from here we can rewrite it as quarterly, monthly, etc... using the above commands. There are 3 different considerations depending on how your existing “date variable” is set up:

1. Date functions for single string variables

For example, your existing date variable is called `raw_date` and is of the form “20mar1999” – then it is said to be a single string variable (the string must be easily separated into its components so strings like “20mar1999” and “March 20, 1999” are acceptable). If you have a string like “200399”, we would need to convert it to a numeric variable first and then use technique 3 below.

To convert the `raw_date` variable to a daily time-series date, we use the command:

```
gen daily=date(raw_date,"dmy")
```

The “dmy” portion indicates the order of the day, month and year in the variable; so if the variable was of the form values been coded as “March 20, 1999” we would have used “mdy” instead.

The year must have 4 digits or else it returns missing values – therefore if the original date only has two digits, we place the century before the “y.”:

```
gen daily=date(raw_date,"dm19y")
```

Or, if we have non-daily dates, we can use the following functions:

```
weekly(stringvar,"wy")
monthly(stringvar,"my")
quarterly(stringvar,"qy")
halfyearly(stringvar,"hy")
yearly(stringvar,"y")
```

For example, if our data is 2002Q1, then

```
gen quarterly= quarterly(raw_data, "yq")
```

will get our elapsed quarters since 1960 Q1.

2. Date functions for partial date variables

If there are separate variables for each element of the date; for example:

month	day	year
7	11	1948
1	21	1952
11	2	1994
8	12	1993

We can use the `mdy()` function to create an elapsed Stata date variable. The month, day and year variables must be numeric. Therefore we can write:

```
gen mydate = mdy(month, day, year)
```

Or, with quarterly data, we would use the `yq()` function:

```
gen qtr=yq(year, quarter)
```

All of the functions are:

<code>mdy(month, day, year)</code>	for daily data
<code>yw(year, week)</code>	for weekly data
<code>ym(year, month)</code>	for monthly data
<code>yq(year, quarter)</code>	for quarterly data
<code>yh(year, half-year)</code>	for half-yearly data

3. Converting a date variable stored as a single number

As discussed above, if you have a single numeric variable, we need to first convert it into its component parts in order to use the `mdy` function. For example, imagine the variable is of the form `yyyymmdd` (for example, 19990320 for March 20 1999); now we need to split it into year, month and day as follows:

```
gen year = int(date/10000)
gen month = int((date-year*10000)/100)
gen day = int((date-year*10000-month*100))
gen mydate = mdy(month, day, year)
```

In each case the `int(x)` command returns the integer obtained by truncating `x` towards zero.

Using the time series date variables

Once we have the date variable in Stata elapsed time form, it is not the most intuitive to work with. For example, here is how a new variable called `stata_date` will look by using the command

```
gen stata_date = mdy(month, day, year)
```

month	day	year	stata_date
7	11	1948	-4191
1	21	1952	-2902
8	12	1993	12277
11	2	1994	12724

Therefore to display the `stata_date` in a more user-friendly manner, we can use the `format` command as follows:

```
format stata_date %d
```

This means that `stata_date` will now be displayed as:

month	day	year	stata_date
7	11	1948	11jul1948
1	21	1952	21jan1952
8	12	1993	12aug1993
11	2	1994	02nov1994

It is possible to use alternatives to `%d`, or to use `%td` to display elapsed dates in numerous other ways – in fact, we can control everything about the display. For example if I had instead written:

```
format stata_date %dM_d,_CY
```

Then we would get:

month	day	year	stata_date
7	11	1948	July 11, 1948
1	21	1952	January 21, 1952
8	12	1993	August 12, 1993
11	2	1994	November 2, 1994

Making use of Dates

If we want to use our dates in an `if` command, we have a number of options:

1. Exact dates

We have a selection of functions `d()`, `w()`, `m()`, `q()`, `h()`, and `y()` to specify exact daily, weekly, monthly, quarterly, half-yearly, and yearly dates respectively. For example:

```
reg x y if w(1995w9)
sum income if q(1988-3)
tab gender if y(1999)
```

2. A date range

If you want to specify a range of dates, you can use the `tin()` and `twwithin()` functions:

```
reg y x if tin(01feb1990,01jun1990)
sum income if twwithin(1988-3,1998-3)
```

The difference between `tin()` and `twwithin()` is that `tin()` includes the beginning and end dates, whereas `twwithin()` excludes them. Always enter the beginning date first, and write them out as you would for any of the `d()`, `w()`, etc. functions.

Time-series tricks using Dates

Often in time-series analyses we need to "lag" or "lead" the values of a variable from one observation to the next. Or we need to take first, second or seasonal differences. One way to do this is to generate a whole bunch of variables which represent the lag or the lead, the difference, etc... But if we have many variables, this can be take up a lot of memory.

You should use the `tsset` command before any of the "tricks" in this section will work. This has the added advantage that if you have defined your data as a panel, Stata will automatically re-start any calculations when it comes to the beginning of a new cross-sectional unit so you need not worry about values from one panel being carried over to the next.

- Lags and Leads

These use the `L.varname` (to lag) and `F.varname` (to lead) commands. Both work the same way:

```
reg income L.income
```

This regresses `income(t)` on `income(t-1)`

If you wanted to lag income by more than one time period, you would simply change the L. to something like "L2." or "L3." to lag it by 2 and 3 time periods respectively.

- Differencing

Used in a similar way, the *D.varname* command will take the first difference, *D2.varname* will take the double difference (difference in difference), etc... For example:

Date	income	D.income	D2.income
02feb1999	120	.	.
02mar1999	230	110	.
02apr1999	245	15	5

- Seasonal Differencing

The *S.varname* command is similar to the *D.varname*, except that the difference is always taken from the current observation to the n-th observation: In other words: *S.income*=*income*(t)-*income*(t-1) and *S2.income*=*income*(t)-*income*(t-2)

Date	income	S.income	S2.income
02feb1999	120	.	.
02mar1999	230	110	.
02apr1999	245	15	125

Survey data

Survey data is very common in many applied microeconomic settings. Labour Economics, Economics of Education, Industrial Organization, all these fields employ surveys regularly. To minimize costs surveys are often designed such that the whole population is split into several strata and within these strata sampling (with differing probabilities) takes place. As an example we can consider so called linked employer-employee (LEE) data. This type of data is very useful for several fields of economics. You can e.g. in labour economics control for firm effects, productivity indicators or capital, or in industrial economics control for workforce characteristics. A good overview of the issues involved can be found at <http://www2.napier.ac.uk/depts/fhls/peas/theory.asp>.

The sampling for LEE data is usually conducted in two stages. First a sample of firms is selected and in the second stage employees within these firms are randomly sampled. If this method would be conducted without stratification, it would be very unlikely that very large firms (of which there are only a few) would be part of our sample. So in order to be able to make statements about all firms in a country we would need a very large sample so that the probability that we observe a few very large firms is not zero. An easier method would be to split the population of all firms into small, medium and large firms and draw independent samples from each of these groups (or strata as they are called in Stata).

Conversely we would want to sample a share of employees that is inversely related to the size of the firm. If we would for example set the share of surveyed employees in a firm to ten percent, we would only get responses from 1 or 2 employees in very small firms, a number that will not let us infer anything on the firm's total workforce. For large firms ten percent might even be too large a number (think General Electric). So we will have to use different sampling probabilities (the inverse of which are the sampling weights – pweight). Note that we could also apply different sampling probabilities within each stratum, if we have a lot more small than medium and large firms we might want to sample less from that category.

Besides weights and strata Stata can also account for clustering. Clusters arise by sampling groups of individuals (e.g. employees from a firm, children from a school or from a class, households from a district). In our example we sample individuals from firms and set this as our clustering variable.

The dataset would be provided with a firm indicator, the inverse sampling probability of the firm (the sampling weight), information on the strata (which we can use to construct a stratum indicator dummy) and sampling weights for the workers. If there is no overall sampling weight we can generate it by multiplying firm and worker sampling weights (careful when working with weights, in Stata the sampling weight is the inverse sampling probability).

In order to get point estimates right you need to use sampling weights, clustering and stratification (as well as sampling weights) matter for the correct estimation of standard errors.

```
. svyset firm_id [pweight=total_w], strata(firm_size_cat) || _n
```

In small samples we might want to add a finite population correction. This will affect the standard errors, but only in small populations (see the PEAS website). For the first stage this is no problem in our artificial example. We generate a variable that tells Stata the share of the population that the cluster is representing (i.e. the sampling probability) and we are done.

```
. gen double firm_sp = 1/firm_w  
. svyset firm_id [pweight=total_w], strata(firm_size_cat) fpc(firm_sp) || _n
```

For the second stage things get a little trickier, the variable that indicates the finite population may not vary within a stratum. If this is the case and the probability of an employee to be part of the sample is the same for each employee in the same stratum it suffices to specify the `fpc()` option using the workers sampling probability. If not, it might be that the second stage is stratified as well, for example we might have first stage strata defined by industry and region of a firm and after selecting the firms we stratify by firm size for the second stage.

```
. svyset firm_id [pweight=total_w], strata(firm_ind_reg_cat) fpc(firm_sp) || _n,  
strata(firm_size_cat) fpc(worker_sp)
```

The number of commands that support the survey option is constantly increasing (the number more than doubled from Stata 9 to Stata 10). All the basic estimation commands (ordinary least squares, instrumental variable estimation, logit and probit models and many more) are supported by `svy`. To account for the survey properties we simply use the `svy` prefix:

```
. svy: regress y x
```