MODULE ONE, PART TWO: READING DATA INTO LIMDEP, CREATING AND RECODING VARIABLES, AND ESTIMATING AND TESTING MODELS IN LIMDEP

This Part Two of Module One provides a cookbook-type demonstration of the steps required to read or import data into LIMDEP. The reading of both small and large text and Excel files are shown though real data examples. The procedures to recode and create variables within LIMDEP are demonstrated. Commands for least-squares regression estimation and maximum likelihood estimation of probit and logit models are provided. Consideration is given to analysis of variance and the testing of linear restrictions and structural differences, as outlined in Part One. (Parts Three and Four provide the STATA and SAS commands for the same operations undertaken here in Part Two with LIMDEP. For a thorough review of LIMDEP, see Hilbe, 2006.)

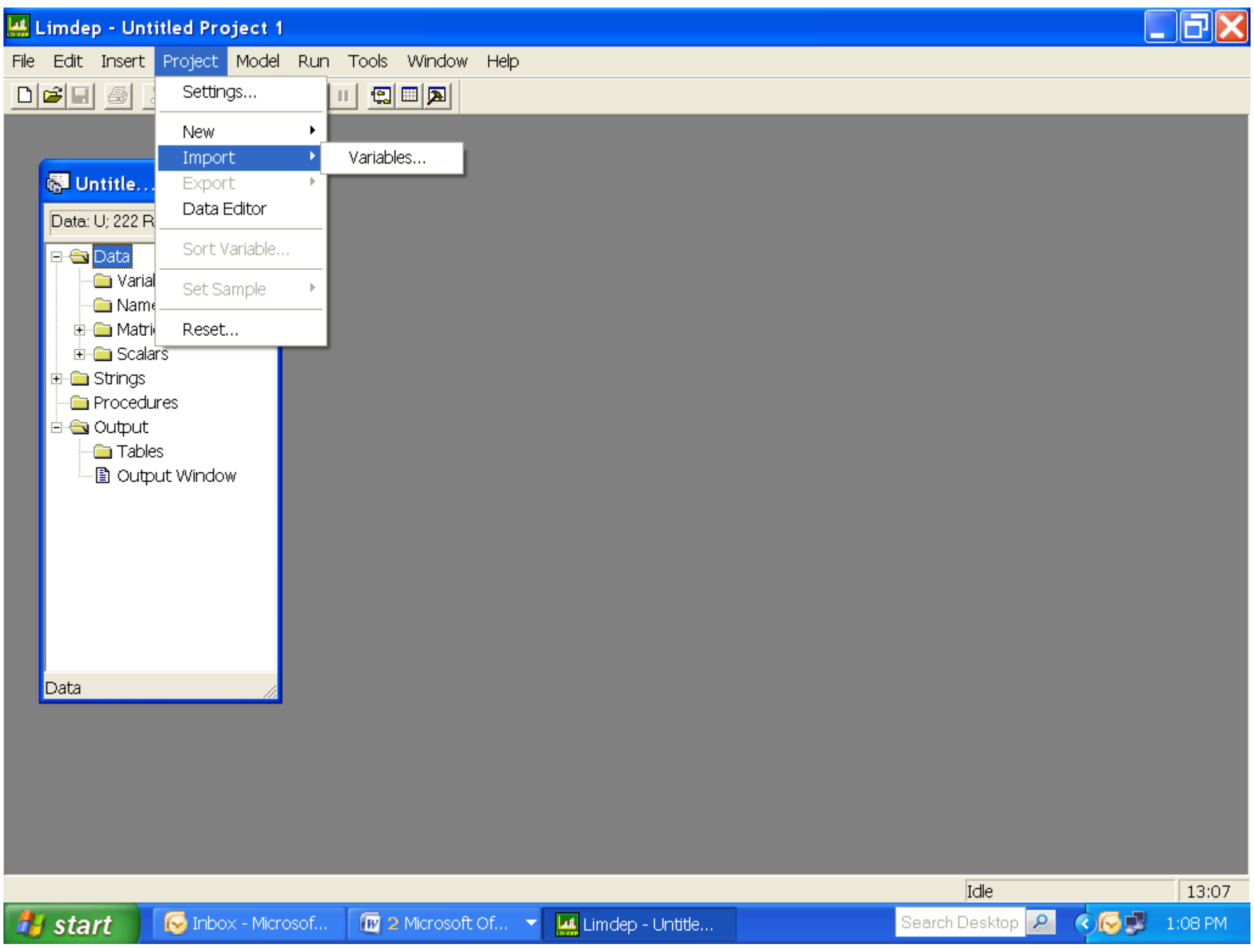
IMPORTING EXCEL FILES INTO LIMDEP

LIMDEP can read or import data in several ways. The most easily imported files are those created in Microsoft Excel with the ".xls" file name extension. To see how this is done, consider the data set in the Excel file "post-pre.xls," which consists of test scores for 24 students in four classes. The column titled "Student" identifies the 24 students by number, "post" provides each student's post-course test score, "pre" is each student's pre-course test score, and "class" identifies to which one of the four classes the students was assigned, e.g., class4 = 1 if student was in the fourth class and class4 = 0 if not. The "." in the post column for student 24 indicates that the student is missing a post-course test score.

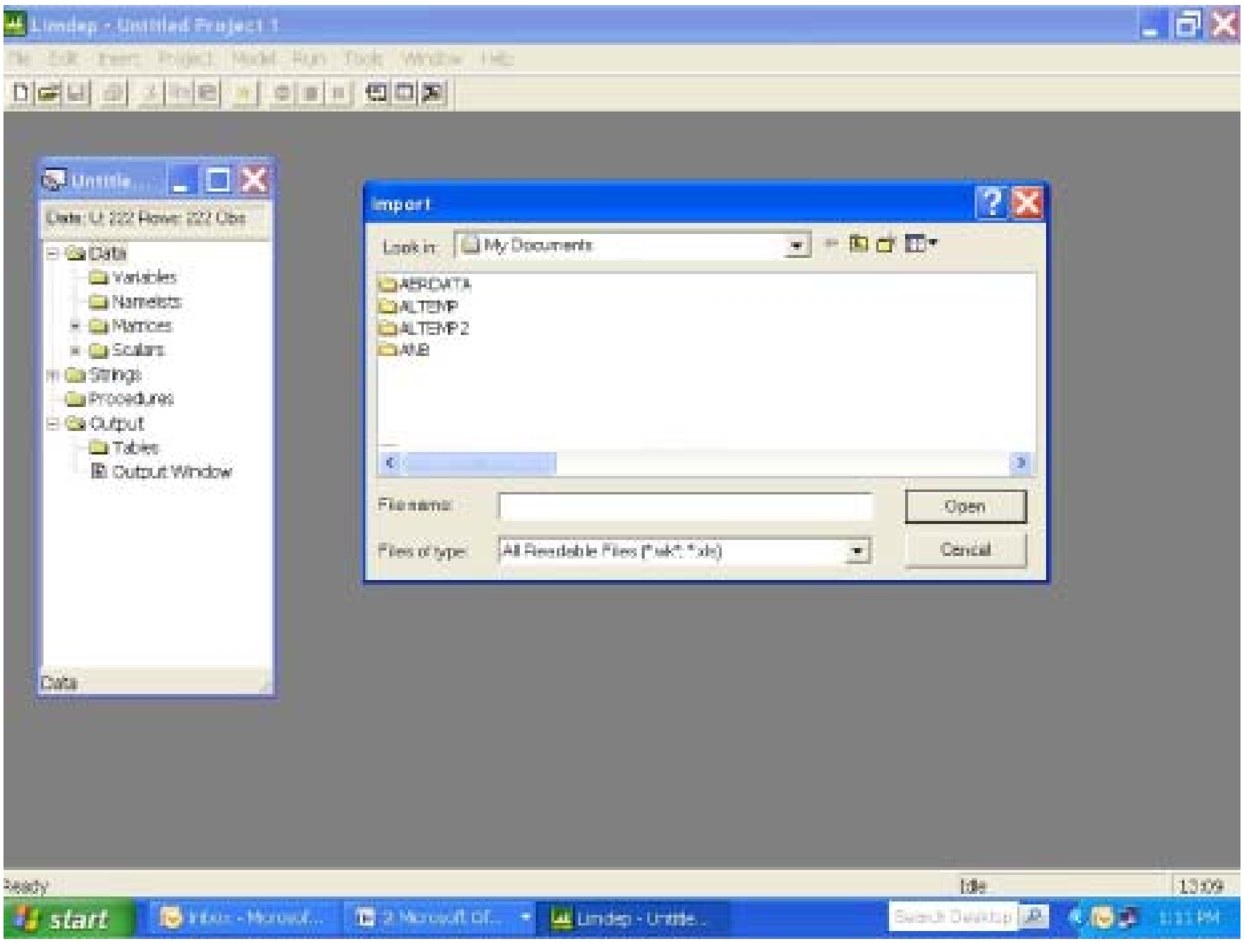
student	post	pre	class1	class2	class3	class4
1	31	22	1	0	0	0
2	30	21	1	0	0	0
3	33	23	1	0	0	0
4	31	22	1	0	0	0
5	25	18	1	0	0	0
6	32	24	0	1	0	0
7	32	23	0	1	0	0
8	30	20	0	1	0	0
9	31	22	0	1	0	0
10	23	17	0	1	0	0

11	22	16	0	1	0	0
12	21	15	0	1	0	0
13	30	19	0	0	1	0
14	21	14	0	0	1	0
15	19	13	0	0	1	0
16	23	17	0	0	1	0
17	30	20	0	0	1	0
18	31	21	0	0	1	0
19	20	15	0	0	0	1
20	26	18	0	0	0	1
21	20	16	0	0	0	1
22	14	13	0	0	0	1
23	28	21	0	0	0	1
24	.	12	0	0	0	1

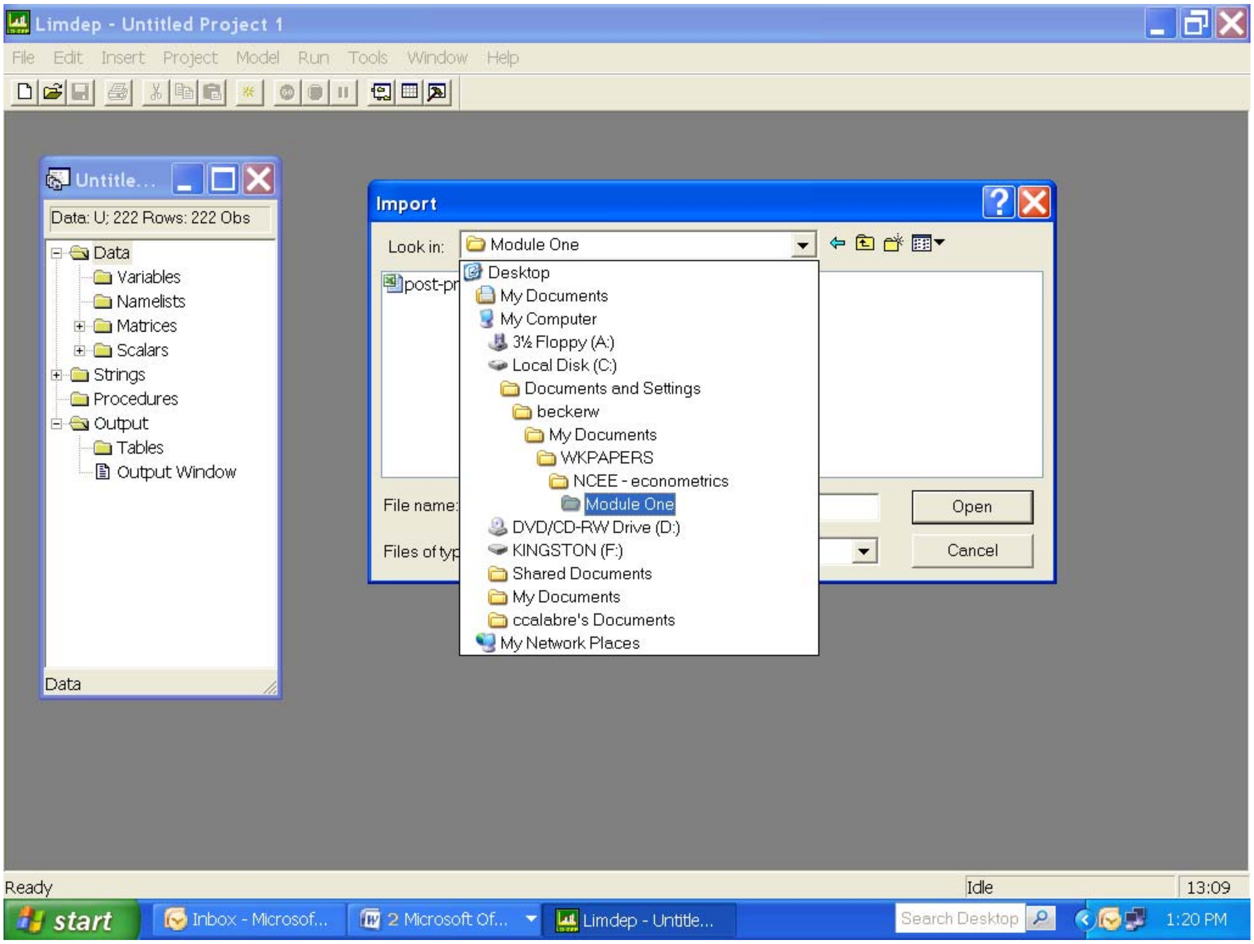
To start, the file "post-pre.xls" must be downloaded and copied to your computer's hard drive. Once this is done open LIMDEP. Clicking on "Project," "Import," and "Variables…" yields the following screen display:



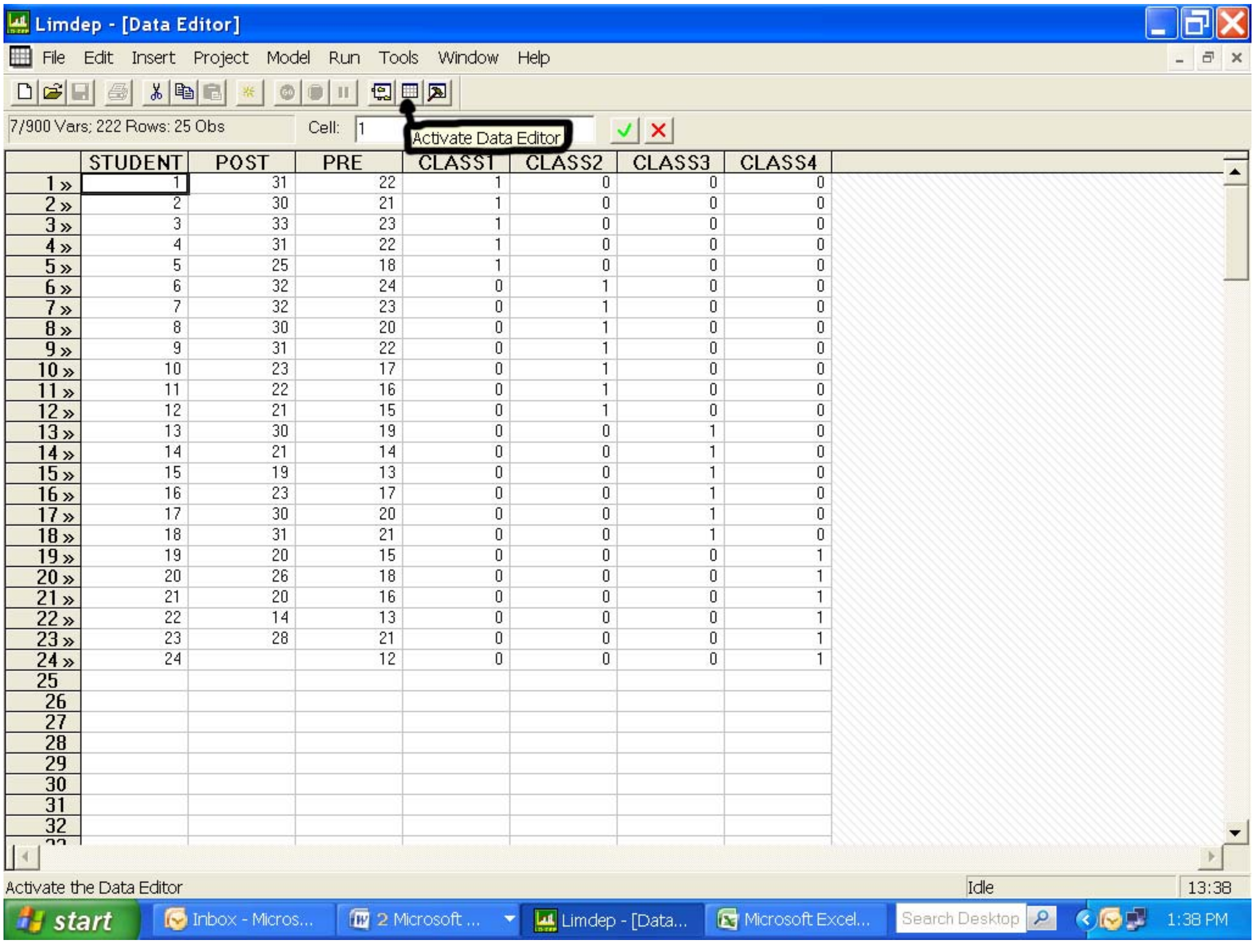
Clicking "Variable" gives a screen display of your folders in "My Documents," in which you can locate files containing Excel (.wk and .xls) files.



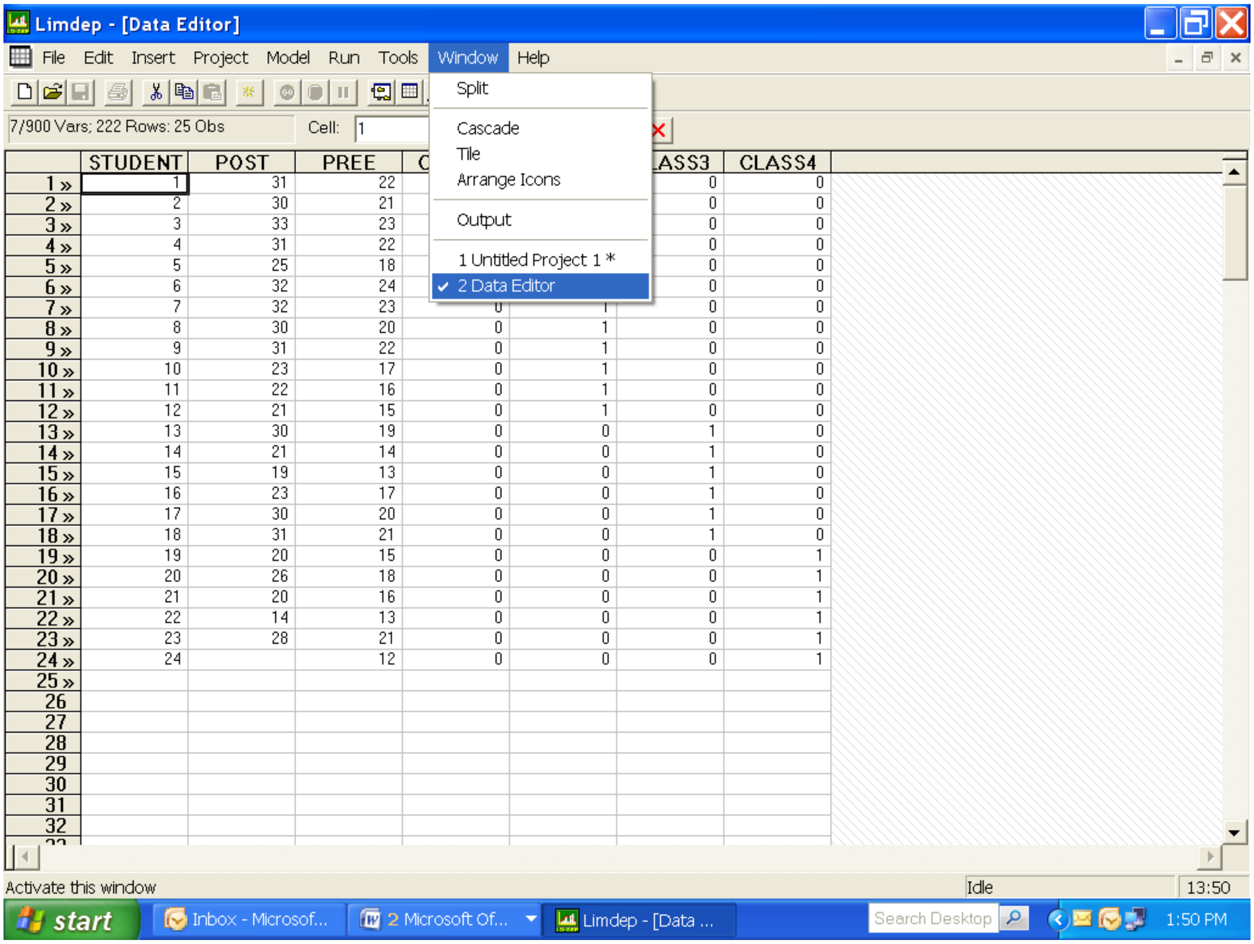
The next slide shows a path to the file "post-pre.xls." (The path to your copy of "post-pre.xls" will obviously depend on where you placed it on your computer's hard drive.) Clicking "Open" imports the file into LIMDEP.



To make sure the data has been correctly imported into LIMDEP, click the "Activate Data Editor" button, which is second from the right on the tool bar or go to Data Editor in the Window's menu. Notice that the missing observation for Student 24 appears as a blank in this data editor. The sequencing of these steps and the associated screens follow:

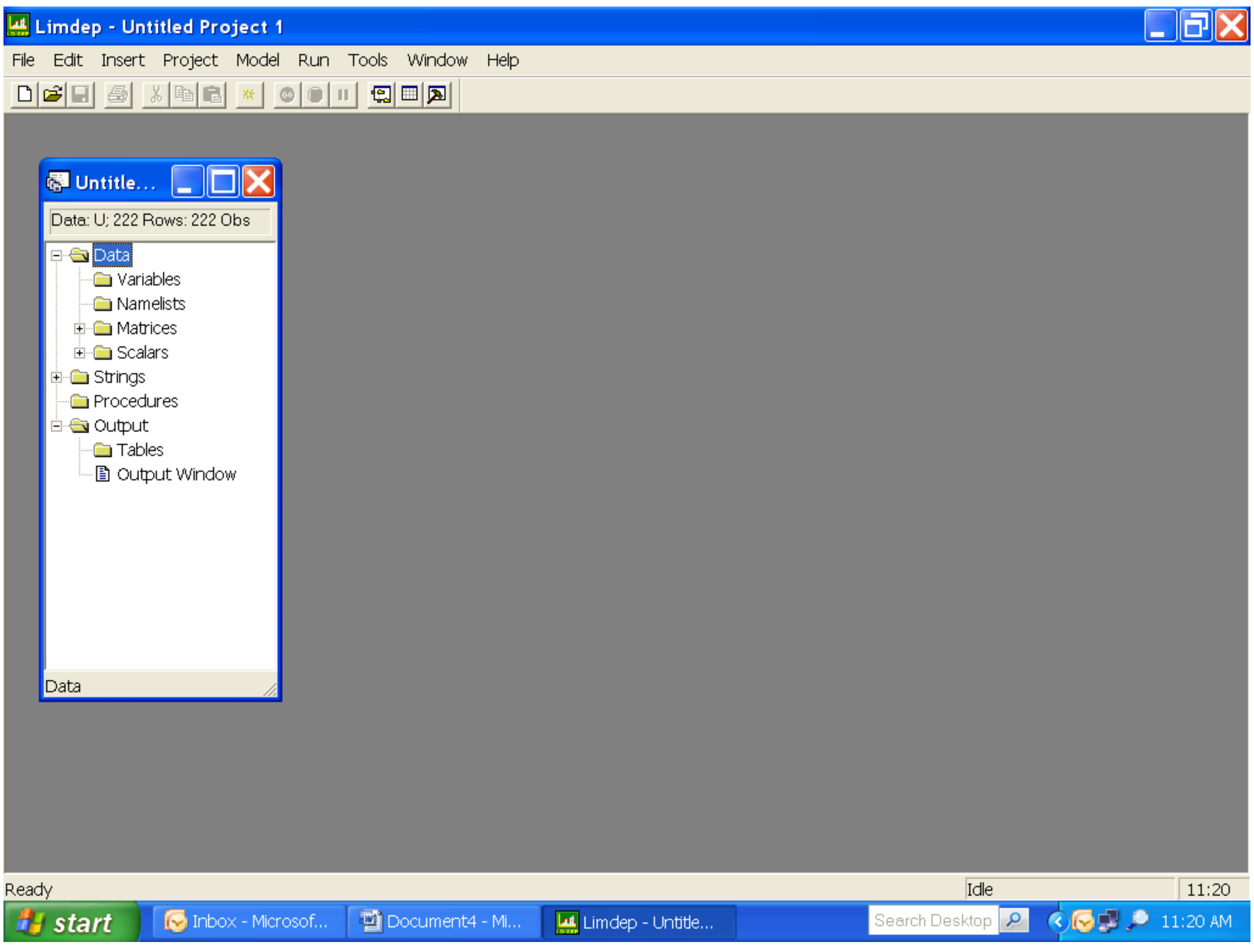


	STUDENT	POST	PRE	CLASS1	CLASS2	CLASS3	CLASS4
1 »	1	31	22	1	0	0	0
2 »	2	30	21	1	0	0	0
3 »	3	33	23	1	0	0	0
4 »	4	31	22	1	0	0	0
5 »	5	25	18	1	0	0	0
6 »	6	32	24	0	1	0	0
7 »	7	32	23	0	1	0	0
8 »	8	30	20	0	1	0	0
9 »	9	31	22	0	1	0	0
10 »	10	23	17	0	1	0	0
11 »	11	22	16	0	1	0	0
12 »	12	21	15	0	1	0	0
13 »	13	30	19	0	0	1	0
14 »	14	21	14	0	0	1	0
15 »	15	19	13	0	0	1	0
16 »	16	23	17	0	0	1	0
17 »	17	30	20	0	0	1	0
18 »	18	31	21	0	0	1	0
19 »	19	20	15	0	0	0	1
20 »	20	26	18	0	0	0	1
21 »	21	20	16	0	0	0	1
22 »	22	14	13	0	0	0	1
23 »	23	28	21	0	0	0	1
24 »	24		12	0	0	0	1
25							
26							
27							
28							
29							
30							
31							
32							

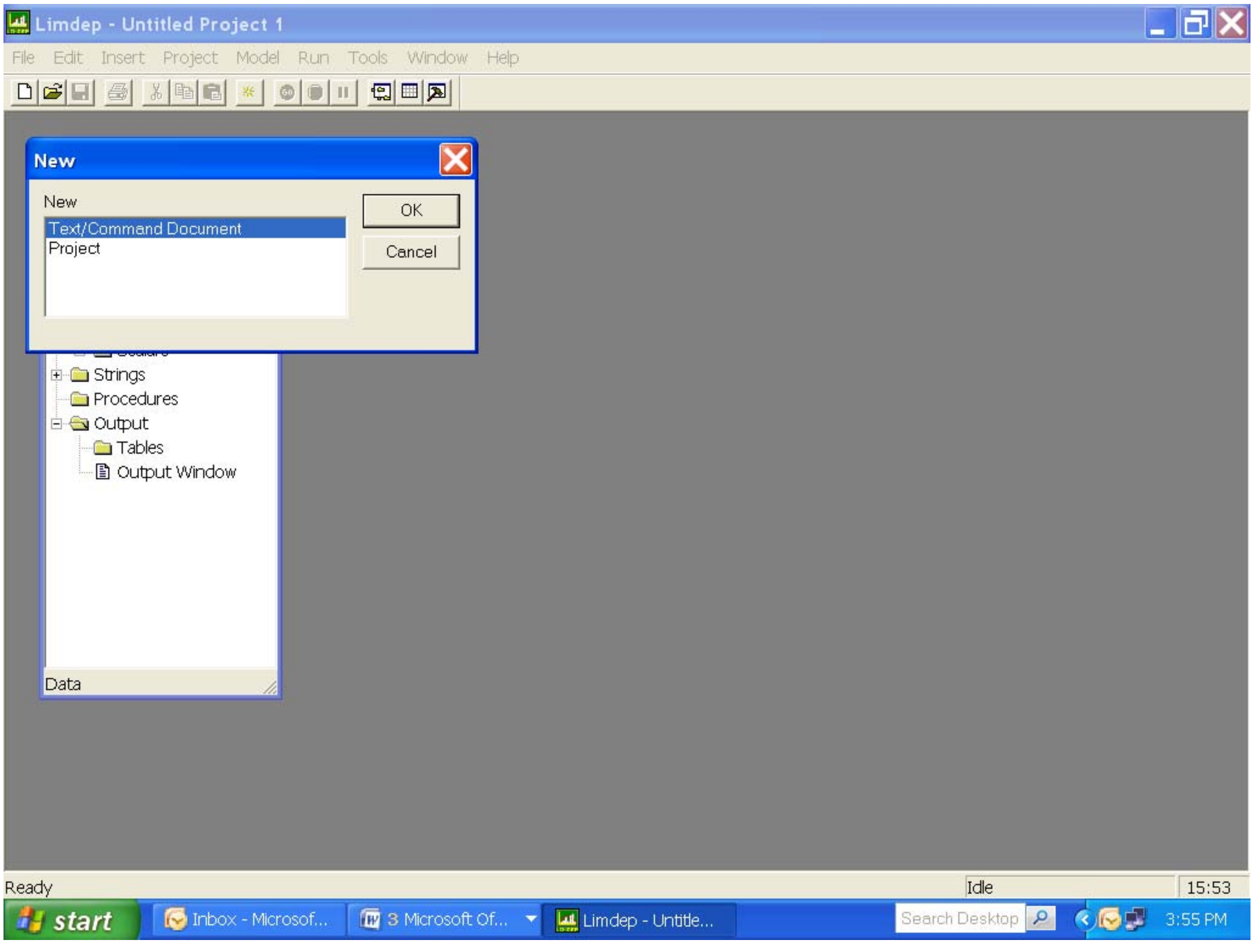

Limdep - [Data Editor]
File Edit Insert Project Model Run Tools Window Help
7/900 Vars; 222 Rows: 25 Obs
Cell: 1
Split
Cascade
Tile
Arrange Icons
Output
1 Untitled Project 1 *
2 Data Editor
STUDENT POST PREE
CLASS4
Activate this window
Idle
13:50
start
Inbox - Microsof...
2 Microsoft Of...
Limdep - [Data ...
Search Desktop
1:50 PM

READING SPACE DELINEATED TEXT FILES INTO LIMDEP

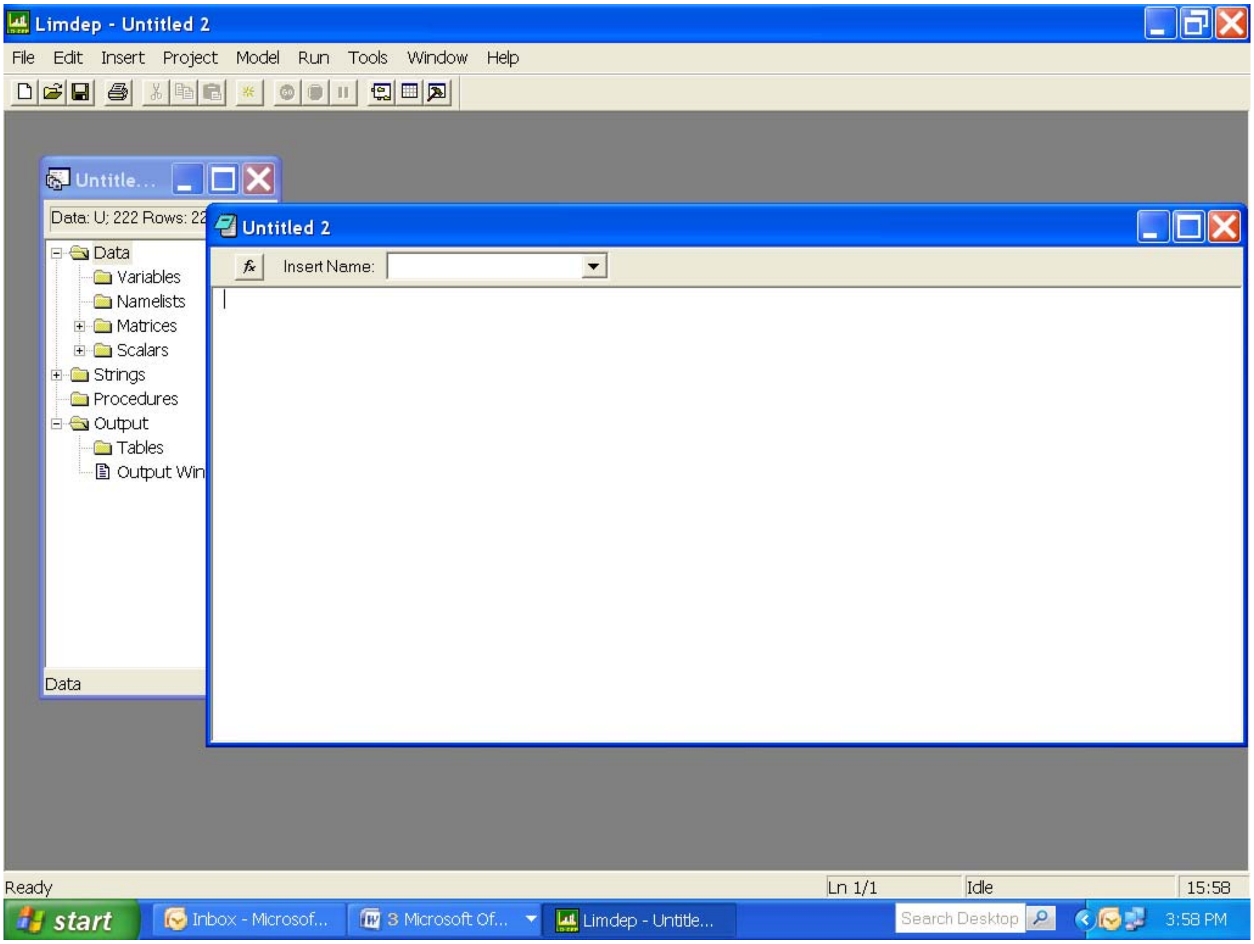
Next we consider externally created text files that are typically accompanied by the ".txt" or ".prn" extensions. For demonstration purposes, the data set we just employed with 24 observations on the 7 variables ("student," "post," "pre," "class1," "class2," "class3," and "class4") was saved as the space delineated text file "post-pre.txt." After downloading this file to your hard drive open LIMDEP to its first screen:



To read the file "post-pre.txt," begin by clicking "File" in the upper left-hand corner of the ribbon, which will yield the following screen display:



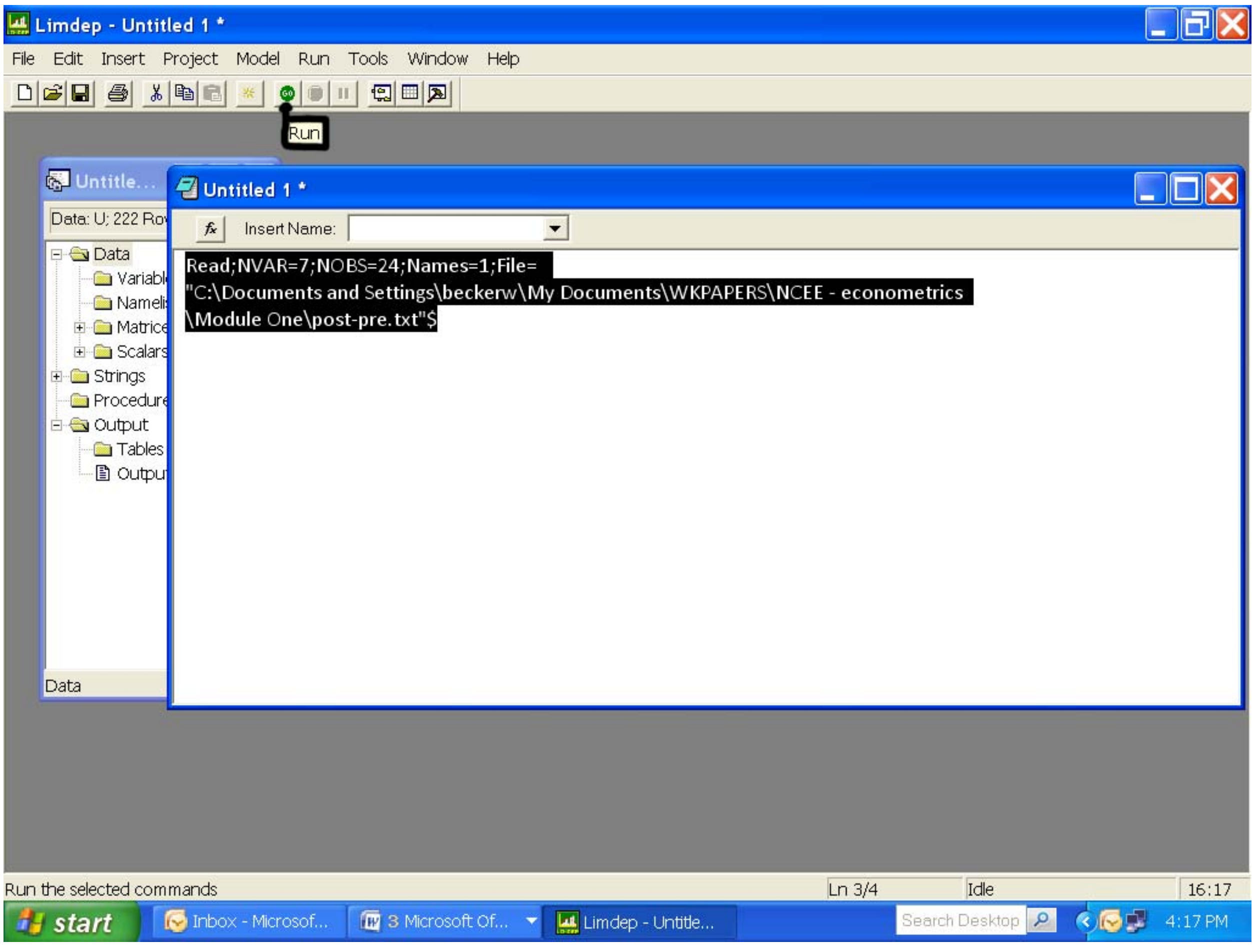
Click on “OK” to “Text/Command Document” to create a file into which all your commands will go.



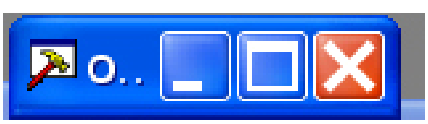
The "read" command is typed or copied into the "Untitled" command file, with all subparts of a command separated with semicolons (;). The program is not case sensitive; thus, upper and lower case letters can be used interchangeably. The read command includes the number of variables or columns to be read (nvar=), the number of records or observations for each variable (nobs=), and the place to find the file (File=). Because the names of the variables are on the first row of the file to be read, we tell this to LIMDEP with the Names=1 command. If the file path is long and involves spaces (as it is here, but your path will depend on where you placed your file), then quote marks are required around the path. The $ indicates the end of the command.

```
Read;NVAR=7;NOBS=24;Names=1;File=
"C:\Documents and Settings\beckerw\My Documents\WKPAPERS\NCEE - econometrics
\Module One\post-pre.txt"$
```

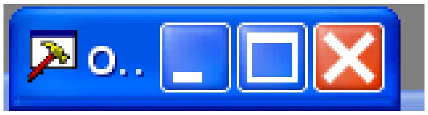
Upon copying or typing this read command into the command file and highlighting the entire three lines, the screen display appears as below and the “Go” button is pressed to run the command.



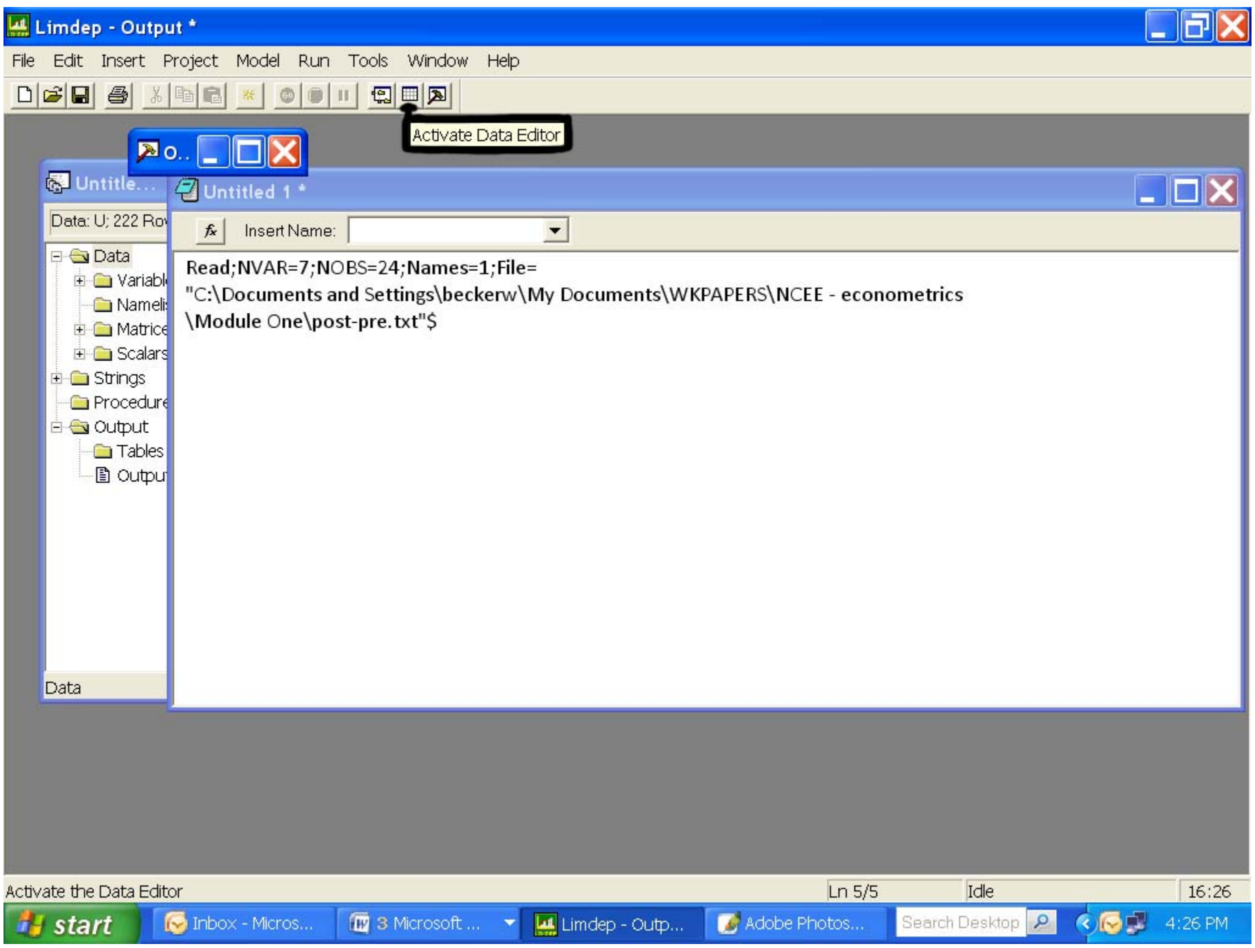
LIMDEP tells the user that it has attempted the command with the appearance of

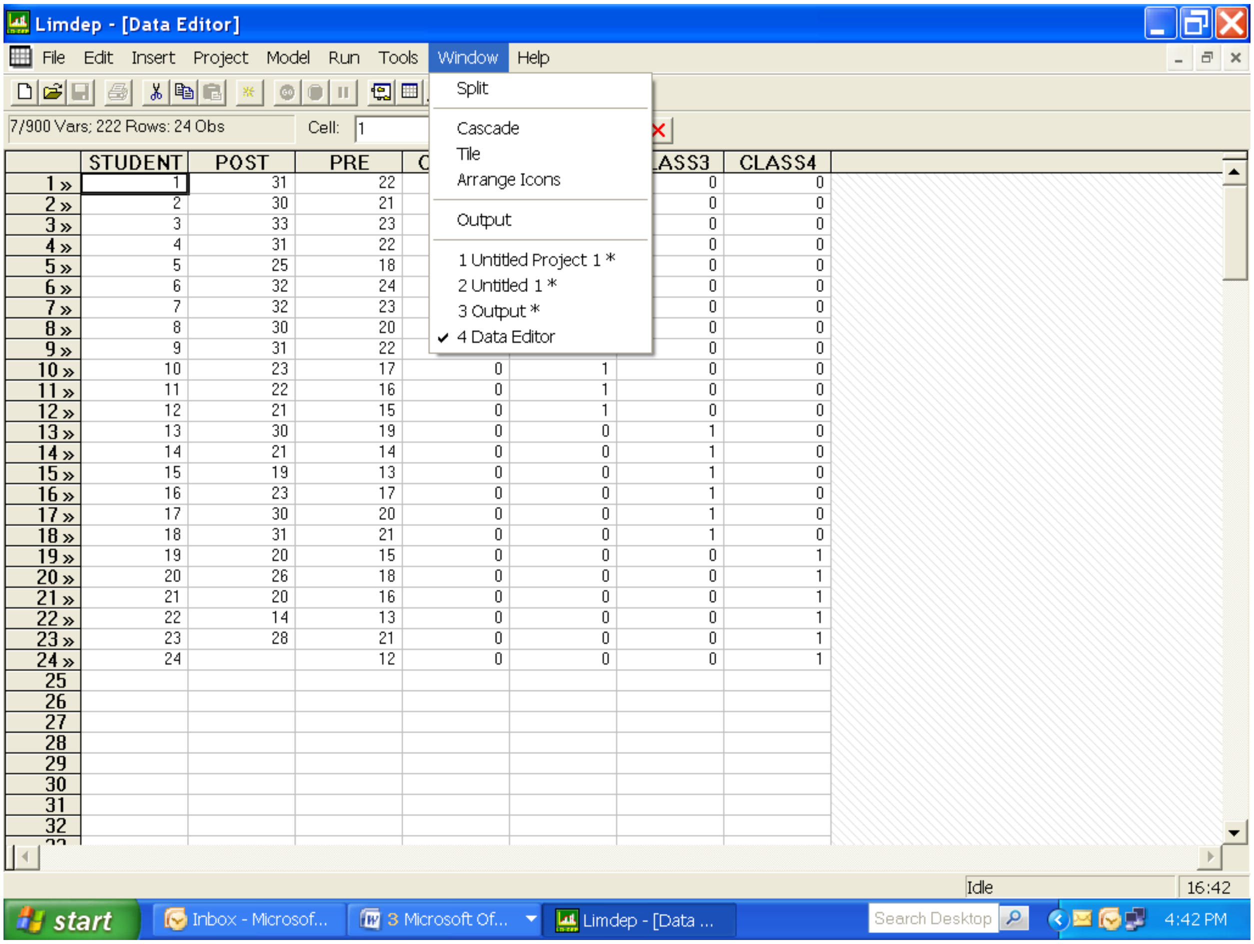


To check on the correct reading of the data, click the “Activate Data Editor” button, which is second from the right on the tool bar or go to Data Editor in the Window’s menu.   Notice that if you use the Window's menus, there are now four files open within Limdep: Untitled Project 1*, Untitled 1*, Output 1*, and Data Editor. As you already know, Untitled 1 contains your read command and Untitled Project is just information in the opening LIMDEP screen. Output contains the commands that LIMDEP has attempted, which so far only includes the read command. This output file could have also been accessed by clicking on the view square next to the X box in the following rectangle



When it appeared to check on whether the read command was properly executed.

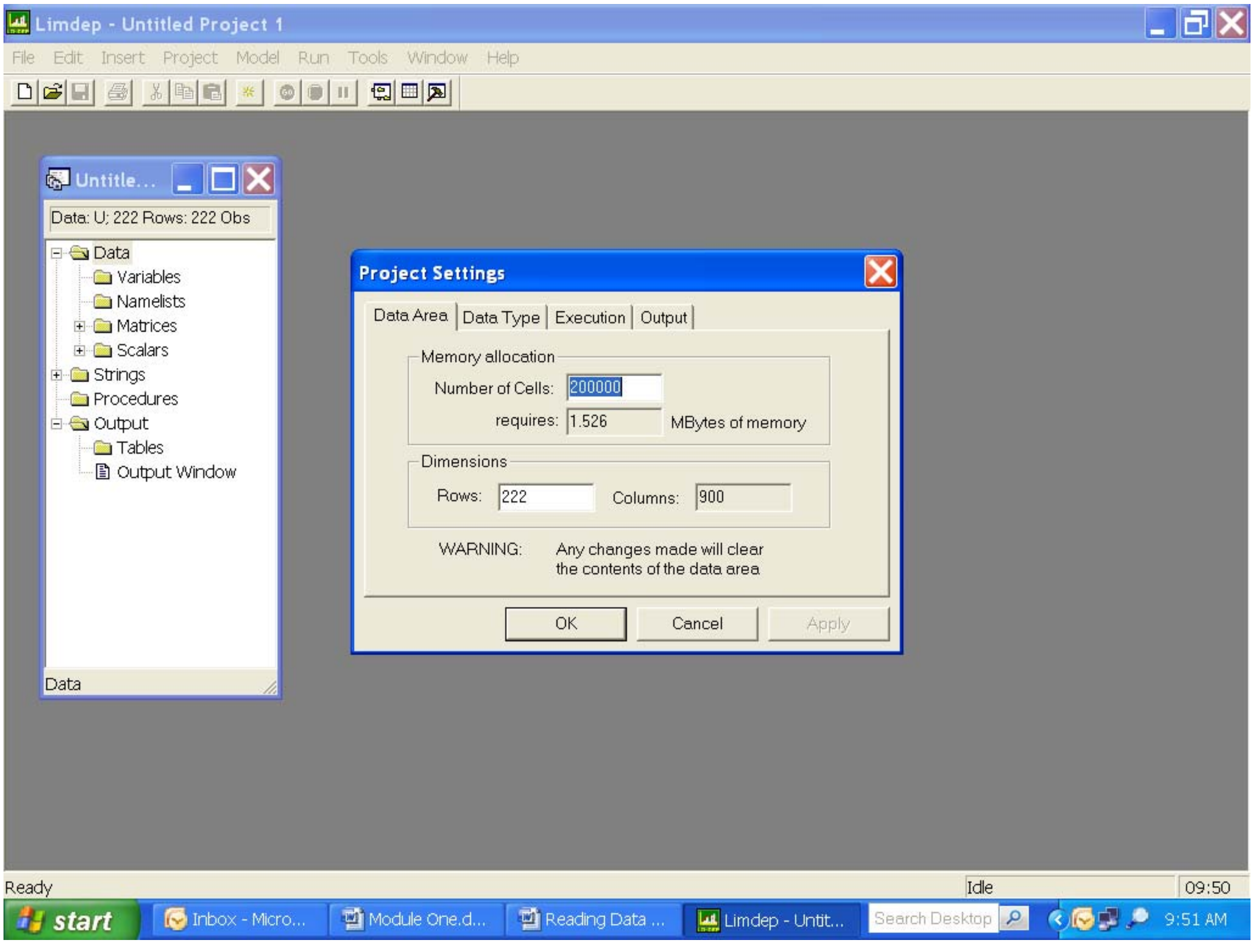




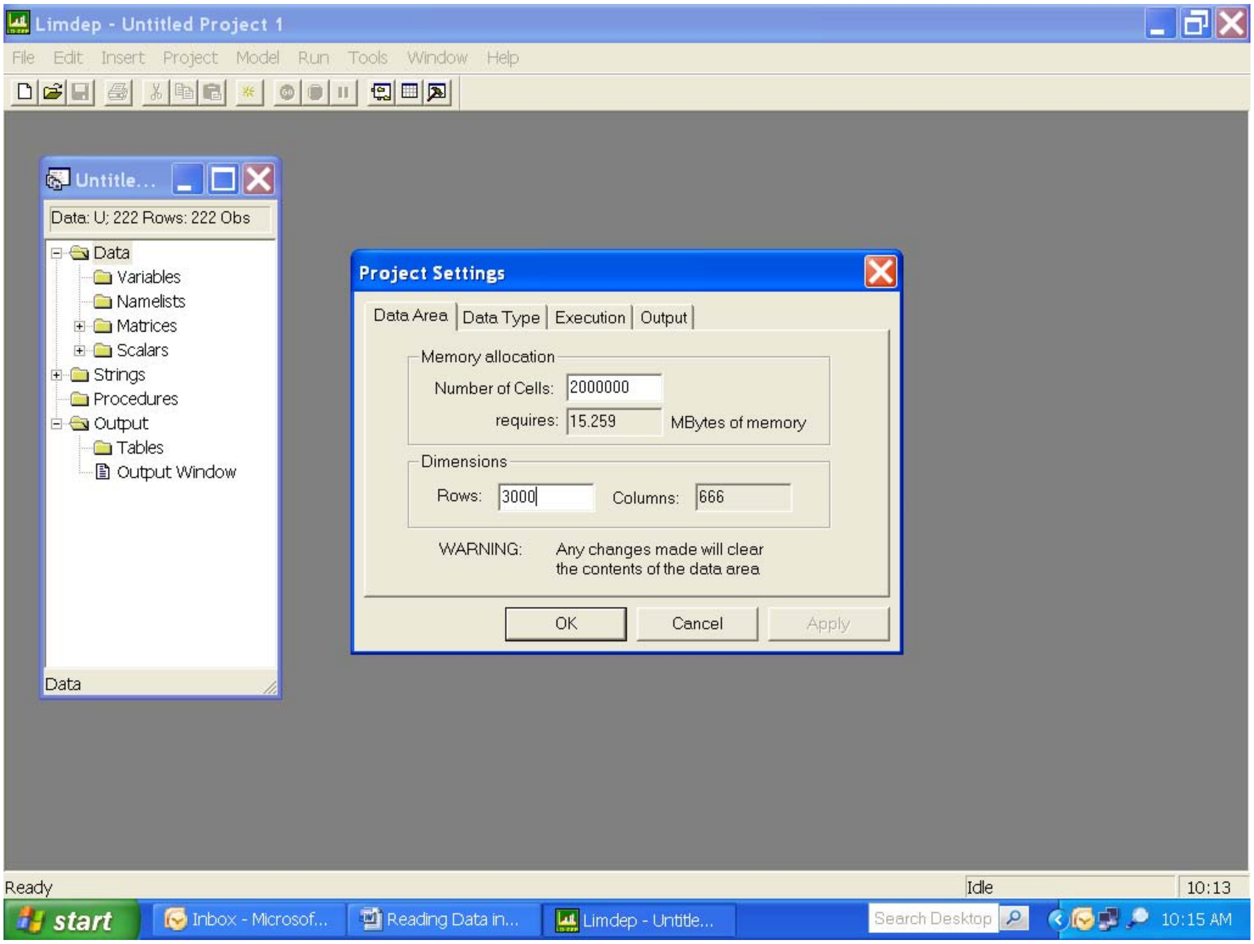
READING LARGE FILES INTO LIMDEP

LIMDEP has a data matrix default restriction of no more than 222 rows (records per variable), 900 columns (number of variables) and 200,000 cells. To read, import or create nonconforming data sets this default setting must be changed. For example, to accommodate larger data sets the number of rows must be increased. If the creation of more than 900 variables is anticipated, even if less than 900 variables were initially imported, then the number of columns must be increased before any data is read. This is accomplished by clicking the project button on the top ribbon, going to settings, and changing the number of cells and number of rows.

As an example, consider the data set employed by Becker and Powers (2001), which initially had 2,837 records. Open LIMDEP and go to "Project" and then "Settings…," which yields the following screen display:



Increasing the “Number of Cells” from 200,000 to 2,000,000 and increasing “Rows” from 222 to 3,000, automatically resets the “Columns” to 666, which is more than sufficient to read the 64 variables in the initial data set and to accommodate any variables to be created within LIMDEP. Pressing “OK” resets the memory allocation that LIMDEP will employ for this data set.



This Becker and Powers data set does not have variable names imbedded in it. Thus, they will be added to the read command. To now read the data follow the path “Files” to “New” to “Text/Command Document” and click “OK.” Entering the following read statement into the Text/Command file, highlighting it, and pushing the green “Go” button will enter the 2,837 records on 64 variables in file beck8WO into LIMDEP and each of the variables will be named as indicated by each two character label.

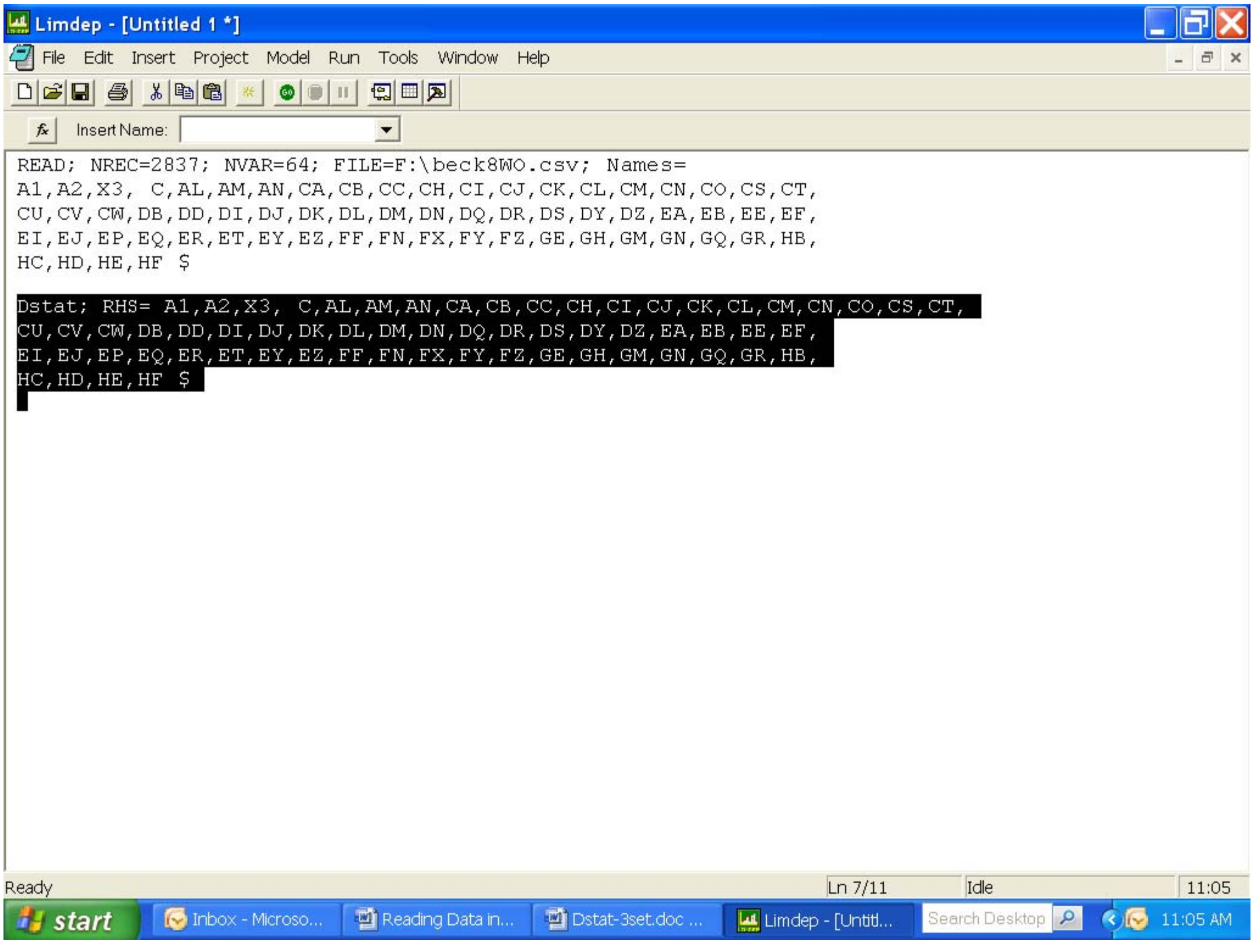
```
READ; NREC=2837; NVAR=64; FILE=F:\beck8WO.csv; Names=
A1,A2,X3, C,AL,AM,AN,CA,CB,CC,CH,CI,CJ,CK,CL,CM,CN,CO,CS,CT,
CU,CV,CW,DB,DD,DI,DJ,DK,DL,DM,DN,DQ,DR,DS,DY,DZ,EA,EB,EE,EF,
EI,EJ,EP,EQ,ER,ET,EY,EZ,FF,FN,FX,FY,FZ,GE,GH,GM,GN,GQ,GR,HB,
HC,HD,HE,HF $
```

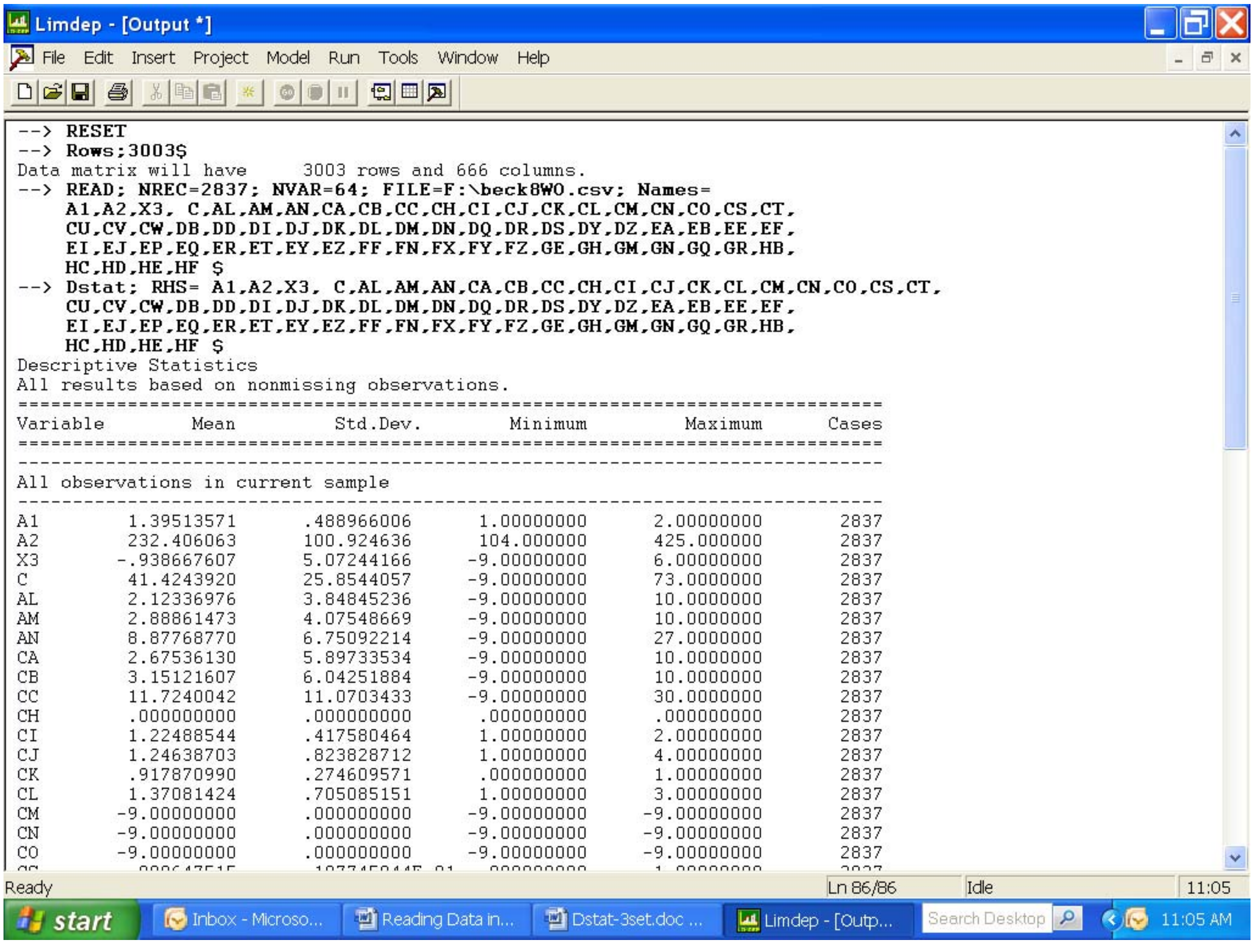
Defining all the variables is not critical for our purposes here, but the variables used in the Becker and Power's study required the following definitions (where names are not upper- and lower-case sensitive):

A1: Term, where 1= fall, 2 = spring
A2: School code, where 100/199 = doctorate, 200/299 = comprehensive, 300/399 = lib arts, 400/499 = 2 year
hb: initial class size (number taking preTUCE)
hc: final class size (number taking postTUCE)
dm: experiences measured by number of years teaching
dj: teacher's highest degree, where Bachelors=1, Masters=2, PhD=3
cc: postTUCE score (0 to 30)
an: preTUCE score (0 to 30)
ge: Student evaluation measured interest
gh: Student evaluation measured textbook quality
gm: Student evaluation measured regular instructor's English ability
gq: Student evaluation measured overall teaching effectiveness
ci: Instructor sex (Male=1, Female=2)
ck: English is native language of instructor (Yes=1, No=0)
cs: PostTUCE score counts toward course grade (Yes=1, No=0)
ff: GPA*100
fn: Student had high school economics (Yes=1, No=0)
ey: Student's sex (Male=1, Female=2)
fx: Student working in a job (Yes=1, No=0)

Notice that this data set is too large to fit in LIMDEP's "Active Data Editor" but all of the data are there as verified with the following DSTAT command, which is entered in the Text/Command file and highlighted. Upon clicking on the Go button, the descriptive statistics for each variable appear in the output file. Again, the output file is accessed via the Window tab in the upper ribbon. (Notice that in this data set, all missing values were coded −9.)

```
Dstat; RHS= A1,A2,X3, C,AL,AM,AN,CA,CB,CC,CH,CI,CJ,CK,CL,CM,CN,CO,CS,CT,
CU,CV,CW,DB,DD,DI,DJ,DK,DL,DM,DN,DQ,DR,DS,DY,DZ,EA,EB,EE,EF,
EI,EJ,EP,EQ,ER,ET,EY,EZ,FF,FN,FX,FY,FZ,GE,GH,GM,GN,GQ,GR,HB,
HC,HD,HE,HF $
```


Limdep - [Untitled 1 *]
File Edit Insert Project Model Run Tools Window Help
Insert Name:
READ; NREC=2837; NVAR=64; FILE=F:\beck8WO.csv; Names=
A1,A2,X3, C,AL,AM,AN,CA,CB,CC,CH,CI,CJ,CK,CL,CM,CN,CO,CS,CT,
CU,CV,CW,DB,DD,DI,DJ,DK,DL,DM,DN,DQ,DR,DS,DY,DZ,EA,EB,EE,EF,
EI,EJ,EP,EQ,ER,ET,EY,EZ,FF,FN,FX,FY,FZ,GE,GH,GM,GN,GQ,GR,HB,
HC,HD,HE,HF $
Dstat; RHS= A1,A2,X3, C,AL,AM,AN,CA,CB,CC,CH,CI,CJ,CK,CL,CM,CN,CO,CS,CT,
CU,CV,CW,DB,DD,DI,DJ,DK,DL,DM,DN,DQ,DR,DS,DY,DZ,EA,EB,EE,EF,
EI,EJ,EP,EQ,ER,ET,EY,EZ,FF,FN,FX,FY,FZ,GE,GH,GM,GN,GQ,GR,HB,
HC,HD,HE,HF $
Ready
Ln 7/11
Idle
11:05
start
Inbox - Microso...
Reading Data in...
Dstat-3set.doc ...
Limdep - [Untitl...
Search Desktop
11:05 AM



In summary, the LIMDEP Help menu states that the READ command is of the general form

READ ; Nobs = number of observations
; Nvar = number of variables
; Names = list of Nvar names
; File = name of the data file $

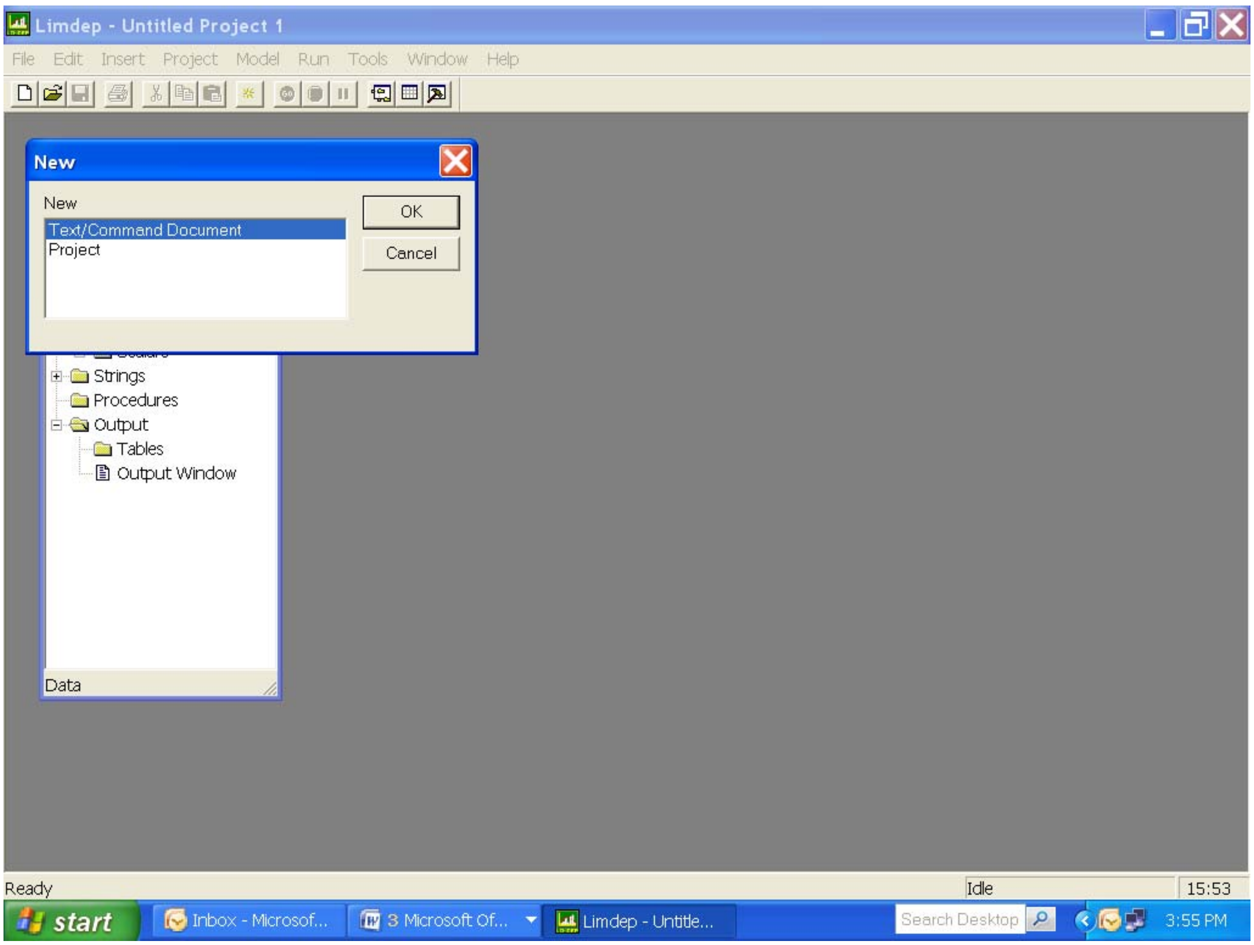
The default is an ASCII (or text) data file in which numbers are separated by blanks, tabs, and/or commas. Although not demonstrated here, LIMDEP will also read formatted files by adding the option "; Format = (Fortran format)" to the read command. In addition, although not demonstrated, small data sets can be cut and pasted directly into the Test/Command Document, preceded by a simple read command "READ ; Nobs = number of observations; Nvar = number of variables$", where ";Names = 1" would also be added if names appear on the line before the data.

LEAST-SQUARES ESTIMATION AND LINEAR RESTRICTIONS IN LIMDEP

To demonstrate some of the least-squares regression commands in LIMDEP, read either the Excel or space delineated text version of the 24 observations and 7 variable "post-pre" data set into LIMDEP. The model to be estimated is

$$post = \beta_1 + \beta_2 pre + f(classes) + \varepsilon$$

All statistical and mathematical instructions must be placed in the "Text/Command Document" of LIMDEP, which is accessed via the "File" to "New" route described earlier:



Once in the "Text/Command Document," the command for a regression can be entered. Before doing this, however, recall that the posttest score is missing for the 24th person, as can be seen in the "Active Data Editor." LIMDEP automatically codes all missing data that appear in a text or Excel file as "." with the value −999. If a regression is estimated with the entire data set, then this fictitious −999 place holding value would be incorrectly employed. To avoid this, all commands can be prefaced with "skip," which tells LIMDEP to not use records involving −999. (In the highly unlikely event that −999 is a legitimate value, then a recoding is required as discussed below.) The syntax for regressions in LIMDEP is

```
Regress; lhs= ???; rhs=one, ??? $
```

where "lhs=" is the left-hand-side dependent variable and "rhs=" is the right-hand-side explanatory variable. The "one" is included on the right-hand-side to estimate a y-intercept. If this "one" is not specified then the regression is forced to go through the origin – that is, no constant term is estimated. Finally, LIMDEP will automatically predict the value of the dependent variable, including 95 percent confidence intervals, and show the results in the output file by adding "fill; list" to the regression command:

```
Regress; lhs= ???; rhs=one, ???; fill; list $
```

To demonstrate some of the least-squares regression commands in LIMDEP read either the Excel or space delineated text version of the 24 observations and 7 variables "post-pre" data set into LIMDEP. The model to be estimated is

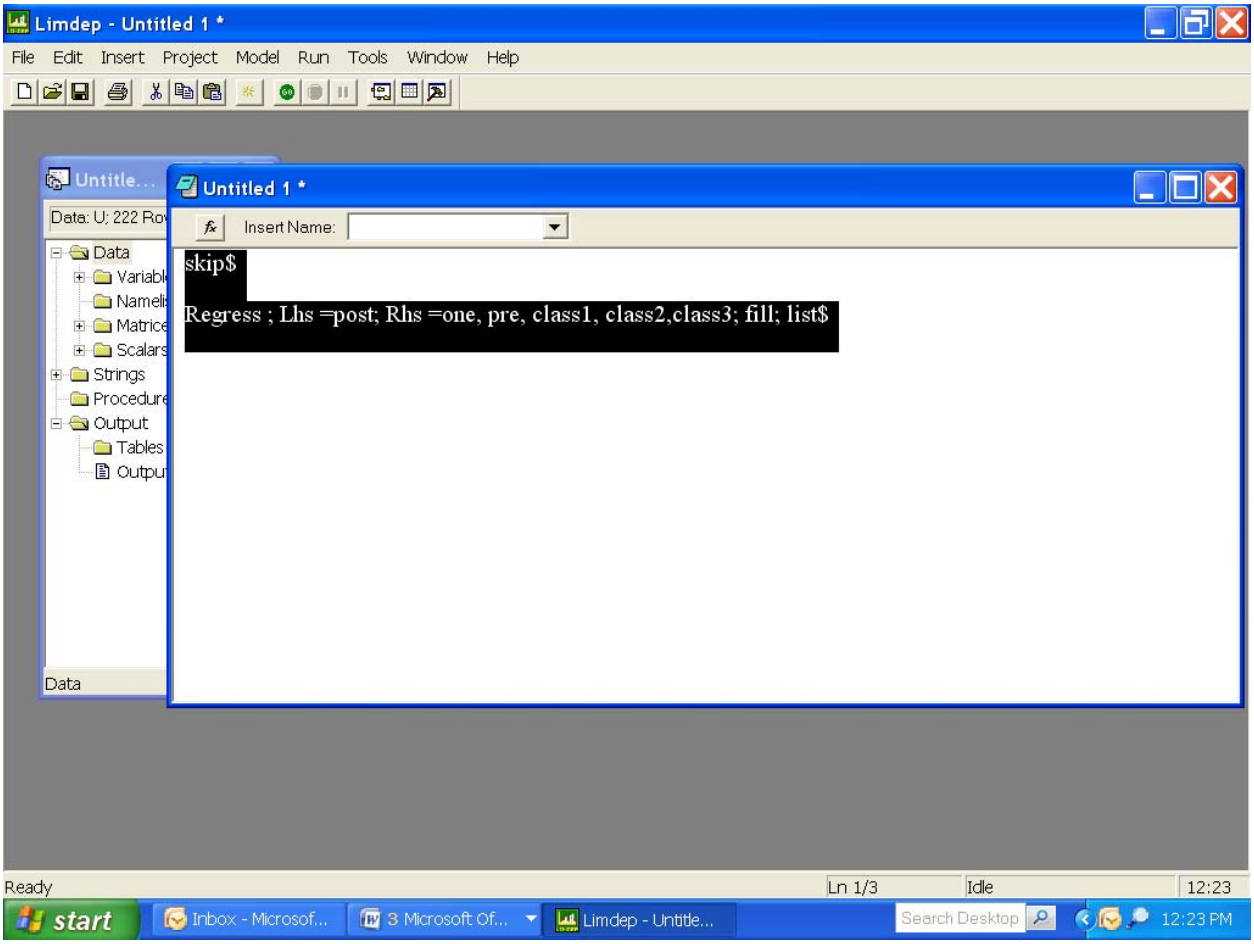
$$post = \beta_1 + \beta_2 pre + \beta_3 class1 + \beta_4 class2 + \beta_5 class3 + \varepsilon$$

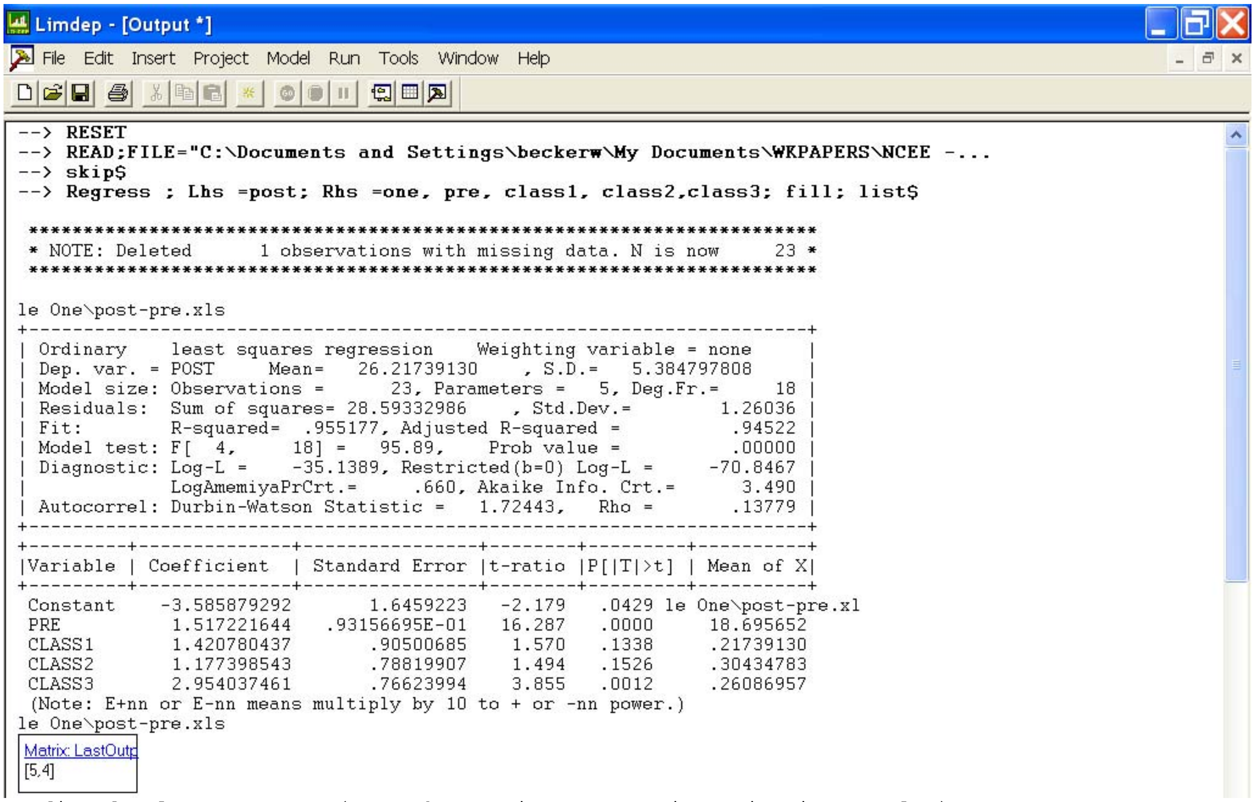
To avoid the sum of the four dummy variables equaling the column of ones in the data set, the fourth class is not included. The commands to be typed into the Untitled Text/Command Document are now

```
skip$

Regress ; Lhs =post; Rhs =one, pre, class1, class2,class3; fill; list$
```

Highlighting these commands and pressing "Go" gives the results in the LIMDEP output file:


Limdep - Untitled 1 *
File Edit Insert Project Model Run Tools Window Help
Untitle...
Data: U; 222 Ro
Data
Variabl
Nameli
Matrice
Scalars
Strings
Procedure
Output
Tables
Outpu
Data
Untitled 1 *
Insert Name:
skip$
Regress ; Lhs =post; Rhs =one, pre, class1, class2,class3; fill; list$
Ready
Ln 1/3
Idle
12:23
start
Inbox - Microsof...
3 Microsoft Of...
Limdep - Untitle...
Search Desktop
12:23 PM




```
--> RESET
--> READ;FILE="C:\Documents and Settings\beckerw\My Documents\WKPAPERS\NCEE -...
--> skip$
--> Regress ; Lhs =post; Rhs =one, pre, class1, class2,class3; fill; list$

 ************************************************************************
 * NOTE: Deleted      1 observations with missing data. N is now     23 *
 ************************************************************************

le One\post-pre.xls
+-----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = POST     Mean=   26.21739130     , S.D.=    5.384797808   |
| Model size: Observations =       23, Parameters =    5, Deg.Fr.=    18 |
| Residuals:  Sum of squares= 28.59332986     , Std.Dev.=        1.26036 |
| Fit:        R-squared=  .955177, Adjusted R-squared =           .94522 |
| Model test: F[  4,     18] =   95.89,    Prob value =           .00000 |
| Diagnostic: Log-L =    -35.1389, Restricted(b=0) Log-L =     -70.8467 |
|             LogAmemiyaPrCrt.=     .660, Akaike Info. Crt.=      3.490 |
| Autocorrel: Durbin-Watson Statistic =    1.72443,   Rho =       .13779 |
+-----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant    -3.585879292       1.6459223    -2.179    .0429 le One\post-pre.xl
 PRE          1.517221644   .93156695E-01   16.287    .0000     18.695652
 CLASS1       1.420780437       .90500685    1.570    .1338     .21739130
 CLASS2       1.177398543       .78819907    1.494    .1526     .30434783
 CLASS3       2.954037461       .76623994    3.855    .0012     .26086957
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
le One\post-pre.xls
Matrix: LastOutp
[5,4]
```

```
Predicted Values          (* => observation was not in estimating sample.)
le One\post-pre.xls
Observation         Observed Y    Predicted Y    Residual    95% Forecast Interval
         1           31.000        31.214         -.2138      28.3089    34.1187
         2           30.000        29.697          .3034      26.7956    32.5975
         3           33.000        32.731          .2690      29.8090    35.6530
         4           31.000        31.214         -.2138      28.3089    34.1187
         5           25.000        25.145         -.1449      22.1774    28.1124
         6           32.000        34.005        -2.0048      31.0444    36.9653
         7           32.000        32.488         -.4876      29.5784    35.3968
         8           30.000        27.936         2.0640      25.1040    30.7679
         9           31.000        30.970          .0296      28.1000    33.8408
        10           23.000        23.384         -.3843      20.5091    26.2594
        11           22.000        21.867          .1329      18.9513    24.7828
        12           21.000        20.350          .6502      17.3811    23.3186
        13           30.000        28.195         1.8046      25.3167    31.0740
        14           21.000        20.609          .3907      17.6757    23.5428
        15           19.000        19.092         -.0920      16.1089    22.0752
        16           23.000        25.161        -2.1609      22.3001    28.0218
        17           30.000        29.713          .2874      26.8053    32.6199
        18           31.000        31.230         -.2298      28.2811    34.1786
        19           20.000        19.172          .8276      16.2549    22.0900
        20           26.000        23.724         2.2759      20.8105    26.6377
        21           20.000        20.690         -.6897      17.7866    23.5927
        22           14.000        16.138        -2.1380      13.1530    19.1230
        23           28.000        28.276         -.2758      25.2500    31.3016
*       24          No data        14.621       No data       11.5836    17.6579
```

From this output the Predicted posttest score is 14.621, with 95 percent confidence interval equal to $11.5836 < E(y|\mathbf{X}_{24}) < 17.6579$.

A researcher might be interested to test whether the class in which a student is enrolled affects his/her post-course test score, assuming fixed effects only. This linear restriction is done automatically in LIMDEP by adding the following "cls:" command to the regression statement in the Text/Command Document.

Regress ; Lhs =post; Rhs =one, pre, class1, class2,class3; CLS: b(3)=0,b(4)=0,b(5)=0$

Upon highlighting and pressing the Go button, the following results will appear in the output file:

```
--> Regress ; Lhs =post; Rhs =one, pre, class1, class2,class3; CLS: b(3)=0,b(...

 ***********************************************************************
 * NOTE: Deleted      1 observations with missing data. N is now     23 *
 ***********************************************************************

le One\post-pre.xls
+----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = POST     Mean=   26.21739130    , S.D.=   5.384797808    |
| Model size: Observations =      23, Parameters =   5, Deg.Fr.=     18 |
| Residuals:  Sum of squares= 28.59332986    , Std.Dev.=       1.26036 |
| Fit:        R-squared=  .955177, Adjusted R-squared =          .94522 |
| Model test: F[  4,     18] =   95.89,    Prob value =          .00000 |
| Diagnostic: Log-L =    -35.1389, Restricted(b=0) Log-L =     -70.8467 |
|             LogAmemiyaPrCrt.=     .660, Akaike Info. Crt.=      3.490 |
| Autocorrel: Durbin-Watson Statistic =   1.72443,   Rho =       .13779 |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant    -3.585879292       1.6459223   -2.179   .0429 le One\post-pre.xl
 PRE          1.517221644   .93156695E-01   16.287   .0000     18.695652
 CLASS1       1.420780437       .90500685    1.570   .1338     .21739130
 CLASS2       1.177398543       .78819907    1.494   .1526     .30434783
 CLASS3       2.954037461       .76623994    3.855   .0012     .26086957
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
le One\post-pre.xls

le One\post-pre.xls
+----------------------------------------------------------------------+
| Linearly restricted regression                                       |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = POST     Mean=   26.21739130    , S.D.=   5.384797808    |
| Model size: Observations =      23, Parameters =   2, Deg.Fr.=     21 |
| Residuals:  Sum of squares= 53.19669876    , Std.Dev.=       1.59160 |
| Fit:        R-squared=  .916608, Adjusted R-squared =          .91264 |
|             (Note:  Not using OLS.  R-squared is not bounded in [0,1] |
| Model test: F[  1,     21] =  230.82,    Prob value =          .00000 |
| Diagnostic: Log-L =    -42.2784, Restricted(b=0) Log-L =     -70.8467 |
|             LogAmemiyaPrCrt.=    1.013, Akaike Info. Crt.=      3.850 |
| Note, when restrictions are imposed, R-squared can be less than zero. |
| F[ 3,    18] for the restrictions =      5.1627, Prob =   .0095       |
| Autocorrel: Durbin-Watson Statistic =   1.12383,   Rho =       .43808 |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant    -2.211829436       1.9004224   -1.164   .2597 le One\post-pre.xl
 PRE          1.520632737       .10008855   15.193   .0000     18.695652
 CLASS1       .0000000000 ........(Fixed Parameter)........   .21739130
 CLASS2   -.4440892099E-15........(Fixed Parameter)........   .30434783
 CLASS3   -.4440892099E-15........(Fixed Parameter)........   .26086957
```

```
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
le One\post-pre.xls
```

From the second part of this printout, the appropriate *F* to test

H_o: $\beta_3 = \beta_4 = \beta_5 = 0$ versus H_a: at least one Beta is nonzero

is *F*[df1=3,df2=18] = 5.1627, with *p*-value = 0.0095. Thus, null hypothesis that none of the dummies is significant at 0.05 Type I error level can be rejected in favor of the hypothesis that at least one class is significant, assuming that the effect of pre-course test score on post-course test score is the same in all classes and only the constant is affected by class assignment.

STRUCTURAL (CHOW) TEST

The above test of the linear restriction $\beta_3 = \beta_4 = \beta_5 = 0$ (no difference among classes), assumed that the pretest slope coefficient was constant, fixed and unaffected by the class to which a student belonged. A full structural test requires the fitting of four separate regressions to obtain the four residual sum of squares that are added to obtain the unrestricted sum of squares. The restricted sum of squares is obtained from a regression of posttest on pretest with no dummies for the classes; that is, the class to which a student belongs is irrelevant in the manner in which pretests determine the posttest score.

The commands to be entered into the Document/text file of LIMDEP are as follows:

Restricted Regression

```
Sample; 1-23$
Regress ; Lhs =post; Rhs =one, pre$
Calc    ; SSall = Sumsqdev$
```

Unrestricted Regressions

```
Sample; 1-5$
Regress ; Lhs =post; Rhs =one, pre$
Calc    ; SS1 = Sumsqdev$

Sample; 6-12$
Regress ; Lhs =post; Rhs =one, pre$
Calc    ; SS2 = Sumsqdev$

Sample; 13-18$
Regress ; Lhs =post; Rhs =one, pre$
Calc    ; SS3 = Sumsqdev$
```

Sample; 19-23$
Regress ; Lhs =post; Rhs =one, pre$
Calc ; SS4 = Sumsqdev$

Calc;List ;F=((SSall-(SS1+SS2+SS3+SS4))/3*2) / ((SS1+SS2+SS3+SS4)/(23-4*2))$

The LIMDEP output is

```
--> RESET
--> READ;FILE="C:\Documents and Settings\beckerw\My Documents\WKPAPERS\NCEE -...
--> Reject; post=-999$
--> Regress ; Lhs =post; Rhs =one, pre, class1, class2,class3; CLS: b(3)=0,b(...

+-----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = POST     Mean=   26.21739130    , S.D.=   5.384797808     |
| Model size: Observations =      23, Parameters =   5, Deg.Fr.=     18 |
| Residuals:  Sum of squares= 28.59332986    , Std.Dev.=        1.26036 |
| Fit:        R-squared=  .955177, Adjusted R-squared =          .94522 |
| Model test: F[  4,     18] =   95.89,    Prob value =          .00000 |
| Diagnostic: Log-L =    -35.1389, Restricted(b=0) Log-L =     -70.8467 |
|             LogAmemiyaPrCrt.=     .660, Akaike Info. Crt.=      3.490 |
| Autocorrel: Durbin-Watson Statistic =   1.72443,   Rho =       .13779 |
+-----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant    -3.585879292       1.6459223   -2.179   .0429
 PRE          1.517221644   .93156695E-01   16.287   .0000     18.695652
 CLASS1       1.420780437       .90500685    1.570   .1338     .21739130
 CLASS2       1.177398543       .78819907    1.494   .1526     .30434783
 CLASS3       2.954037461       .76623994    3.855   .0012     .26086957
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
+-----------------------------------------------------------------------+
| Linearly restricted regression                                        |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = POST     Mean=   26.21739130    , S.D.=   5.384797808     |
| Model size: Observations =      23, Parameters =   2, Deg.Fr.=     21 |
| Residuals:  Sum of squares= 53.19669876    , Std.Dev.=        1.59160 |
| Fit:        R-squared=  .916608, Adjusted R-squared =          .91264 |
|             (Note:  Not using OLS.  R-squared is not bounded in [0,1] |
| Model test: F[  1,     21] =  230.82,    Prob value =          .00000 |
| Diagnostic: Log-L =    -42.2784, Restricted(b=0) Log-L =     -70.8467 |
|             LogAmemiyaPrCrt.=    1.013, Akaike Info. Crt.=      3.850 |
| Note, when restrictions are imposed, R-squared can be less than zero. |
| F[ 3,    18] for the restrictions =      5.1627, Prob =   .0095       |
| Autocorrel: Durbin-Watson Statistic =   1.12383,   Rho =       .43808 |
+-----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant    -2.211829436       1.9004224   -1.164   .2597
 PRE          1.520632737       .10008855   15.193   .0000     18.695652
 CLASS1       .0000000000 ........(Fixed Parameter)........   .21739130
 CLASS2   -.4440892099E-15........(Fixed Parameter)........   .30434783
 CLASS3   -.4440892099E-15........(Fixed Parameter)........   .26086957
```

```
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

--> Sample; 1-23$
--> Regress ; Lhs =post; Rhs =one, pre$

+-----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = POST     Mean=   26.21739130    , S.D.=   5.384797808     |
| Model size: Observations =      23, Parameters =   2, Deg.Fr.=     21 |
| Residuals:  Sum of squares= 53.19669876    , Std.Dev.=        1.59160 |
| Fit:        R-squared=  .916608, Adjusted R-squared =          .91264 |
| Model test: F[  1,     21] =  230.82,    Prob value =          .00000 |
| Diagnostic: Log-L =    -42.2784, Restricted(b=0) Log-L =     -70.8467 |
|             LogAmemiyaPrCrt.=    1.013, Akaike Info. Crt.=      3.850 |
| Autocorrel: Durbin-Watson Statistic =   1.12383,   Rho =       .43808 |
+-----------------------------------------------------------------------+
+---------+-------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+-------------+----------------+--------+---------+----------+
 Constant    -2.211829436       1.9004224   -1.164   .2575
 PRE          1.520632737       .10008855   15.193   .0000     18.695652

--> Calc    ; SSall = Sumsqdev $
--> Sample; 1-5$
--> Regress ; Lhs =post; Rhs =one, pre$

+-----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = POST     Mean=   30.00000000    , S.D.=   3.000000000     |
| Model size: Observations =       5, Parameters =   2, Deg.Fr.=      3 |
| Residuals:  Sum of squares= .2567567568    , Std.Dev.=         .29255 |
| Fit:        R-squared=  .992868, Adjusted R-squared =          .99049 |
| Model test: F[  1,      3] =  417.63,    Prob value =          .00026 |
| Diagnostic: Log-L =       .3280, Restricted(b=0) Log-L =     -12.0299 |
|             LogAmemiyaPrCrt.=   -2.122, Akaike Info. Crt.=       .669 |
| Autocorrel: Durbin-Watson Statistic =   2.19772,   Rho =      -.09886 |
+-----------------------------------------------------------------------+
+---------+-------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+-------------+----------------+--------+---------+----------+
 Constant    -2.945945946       1.6174496   -1.821   .1661
 PRE          1.554054054   .76044788E-01   20.436   .0003     21.200000
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

--> Calc    ; SS1 = Sumsqdev $
--> Sample; 6-12$
--> Regress ; Lhs =post; Rhs =one, pre$

+-----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = POST     Mean=   27.28571429    , S.D.=   5.023753103     |
| Model size: Observations =       7, Parameters =   2, Deg.Fr.=      5 |
| Residuals:  Sum of squares= 7.237132353    , Std.Dev.=        1.20309 |
| Fit:        R-squared=  .952208, Adjusted R-squared =          .94265 |
| Model test: F[  1,      5] =   99.62,    Prob value =          .00017 |
| Diagnostic: Log-L =    -10.0492, Restricted(b=0) Log-L =     -20.6923 |
|             LogAmemiyaPrCrt.=     .621, Akaike Info. Crt.=      3.443 |
| Autocorrel: Durbin-Watson Statistic =   1.50037,   Rho =       .24982 |
+-----------------------------------------------------------------------+
+---------+-------------+----------------+--------+---------+----------+
```

```
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant     .6268382353       2.7094095     .231   .8262
 PRE          1.362132353       .13647334    9.981   .0002     19.571429

--> Calc    ; SS2 = Sumsqdev $
--> Sample; 13-18$
--> Regress ; Lhs =post; Rhs =one, pre$

+-----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = POST     Mean=   25.66666667    , S.D.=   5.278888772     |
| Model size: Observations =       6, Parameters =   2, Deg.Fr.=      4 |
| Residuals:  Sum of squares= 8.081250000    , Std.Dev.=        1.42138 |
| Fit:        R-squared=  .942001, Adjusted R-squared =          .92750 |
| Model test: F[  1,      4] =   64.97,    Prob value =          .00129 |
| Diagnostic: Log-L =     -9.4070, Restricted(b=0) Log-L =     -17.9490 |
|             LogAmemiyaPrCrt.=     .991, Akaike Info. Crt.=      3.802 |
| Autocorrel: Durbin-Watson Statistic =   1.51997,   Rho =       .24001 |
+-----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant    -1.525000000       3.4231291    -.445   .6790
 PRE          1.568750000       .19463006    8.060   .0013     17.333333

--> Calc    ; SS3 = Sumsqdev $
--> Sample; 19-23$
--> Regress ; Lhs =post; Rhs =one, pre$

+-----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = POST     Mean=   21.60000000    , S.D.=   5.549774770     |
| Model size: Observations =       5, Parameters =   2, Deg.Fr.=      3 |
| Residuals:  Sum of squares= 8.924731183    , Std.Dev.=        1.72479 |
| Fit:        R-squared=  .927559, Adjusted R-squared =          .90341 |
| Model test: F[  1,      3] =   38.41,    Prob value =          .00846 |
| Diagnostic: Log-L =     -8.5432, Restricted(b=0) Log-L =     -15.1056 |
|             LogAmemiyaPrCrt.=    1.427, Akaike Info. Crt.=      4.217 |
| Autocorrel: Durbin-Watson Statistic =    .82070,   Rho =       .58965 |
+-----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant    -7.494623656       4.7572798   -1.575   .2132
 PRE          1.752688172       .28279093    6.198   .0085     16.600000

--> Calc    ; SS4 = Sumsqdev $
--> Calc;List ;F=((SSall-(SS1+SS2+SS3+SS4))/(3*2)) / ((SS1+SS2+SS3+SS4)/(23-4*2))$
    F       =  .29282633057790450D+01
```

The structural test across all classes is

$$H_0 : \boldsymbol{\beta}_1 = \boldsymbol{\beta}_2 = \ldots = \boldsymbol{\beta}_4 \text{ and } H_a : \boldsymbol{\beta}'s \text{ are not equal}$$

$$F = \frac{(\mathrm{Re}\,sSS_r - \mathrm{Re}\,sSS_u)/2(J-1K)}{\mathrm{Re}\,sSS_u/(n-JK)}$$

Because the calculated $F = 2.92$, and the critical F (Prob of Type I error =0.05, df1=6, df2=15) = 2.79, we reject the null hypothesis and conclude that at least one class is significantly different from another, allowing the slope on pre-course test score to vary from one class to another. That is, the class in which a student is enrolled is important because of a change in slope and/or the intercept.

HETEROSCEDASTICITY

To adjust for either heteroscedasticity across individual observations or a common error term within groups but not across groups the "hetro" and "cluster" command can be added to the standard "regress" command in LIMDEP in the following manner:

Skip

Regress; Lhs= post; Rhs= one, pre, class1, class2, class3$

Regress; Lhs= post; Rhs= one, pre, class1, class2, class3
;hetro $

Create; Class = class1+2*class2+3*class3+4*class4$
Regress ; Lhs= post; Rhs= one, pre, class1, class2, class3
;cluster=class $

where the "class" variable is created to name the classes 1, 2, 3 and 4 to enable their identification in the "cluster" command.

The resulting LIMDEP output shows a marked increase in the significance of the individual group effects, as reflected in their respective *p*-values.

```
--> RESET
--> READ;FILE="C:\Documents and Settings\beckerw\My Documents\WKPAPERS\NCEE -...
--> skip
--> Regress; Lhs= post; Rhs= one, pre, class1, class2, class3$

 ************************************************************************
 * NOTE: Deleted      1 observations with missing data. N is now     23 *
 ************************************************************************

le One\post-pre.xls
+-----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = POST     Mean=   26.21739130    , S.D.=   5.384797808     |
```

```
| Model size: Observations =      23, Parameters =   5, Deg.Fr.=     18 |
| Residuals:  Sum of squares= 28.59332986    , Std.Dev.=       1.26036 |
| Fit:        R-squared=  .955177, Adjusted R-squared =         .94522 |
| Model test: F[  4,     18] =   95.89,    Prob value =         .00000 |
| Diagnostic: Log-L =    -35.1389, Restricted(b=0) Log-L =     -70.8467 |
|             LogAmemiyaPrCrt.=     .660, Akaike Info. Crt.=      3.490 |
| Autocorrel: Durbin-Watson Statistic =   1.72443,   Rho =       .13779 |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant    -3.585879292       1.6459223   -2.179   .0429 le One\post-pre.xl
 PRE          1.517221644   .93156695E-01   16.287   .0000     18.695652
 CLASS1       1.420780437       .90500685    1.570   .1338      .21739130
 CLASS2       1.177398543       .78819907    1.494   .1526      .30434783
 CLASS3       2.954037461       .76623994    3.855   .0012      .26086957
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
le One\post-pre.xls


--> Regress; Lhs= post; Rhs= one, pre, class1, class2, class3
    ;hetro $

 ************************************************************************
 * NOTE: Deleted      1 observations with missing data. N is now     23 *
 ************************************************************************

le One\post-pre.xls
+----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = POST     Mean=   26.21739130    , S.D.=   5.384797808    |
| Model size: Observations =      23, Parameters =   5, Deg.Fr.=     18 |
| Residuals:  Sum of squares= 28.59332986    , Std.Dev.=       1.26036 |
| Fit:        R-squared=  .955177, Adjusted R-squared =         .94522 |
| Model test: F[  4,     18] =   95.89,    Prob value =         .00000 |
| Diagnostic: Log-L =    -35.1389, Restricted(b=0) Log-L =     -70.8467 |
|             LogAmemiyaPrCrt.=     .660, Akaike Info. Crt.=      3.490 |
| Autocorrel: Durbin-Watson Statistic =   1.72443,   Rho =       .13779 |
| Results Corrected for heteroskedasticity                             |
| Breusch - Pagan chi-squared =     4.0352, with   4 degrees of freedom |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant    -3.585879292       1.5096560   -2.375   .0289 le One\post-pre.xl
 PRE          1.517221644   .72981808E-01   20.789   .0000     18.695652
 CLASS1       1.420780437       .67752835    2.097   .0504      .21739130
 CLASS2       1.177398543       .72249740    1.630   .1206      .30434783
 CLASS3       2.954037461       .80582075    3.666   .0018      .26086957
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
le One\post-pre.xls

--> Create; Class = class1+2*class2+3*class3+4*class4$
--> Regress ; Lhs= post; Rhs= one, pre, class1, class2, class3
    ;cluster=class $

 ************************************************************************
 * NOTE: Deleted      1 observations with missing data. N is now     23 *
 ************************************************************************

le One\post-pre.xls
+----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = POST     Mean=   26.21739130    , S.D.=   5.384797808    |
| Model size: Observations =      23, Parameters =   5, Deg.Fr.=     18 |
```

```
| Residuals:  Sum of squares= 28.59332986    , Std.Dev.=        1.26036 |
| Fit:        R-squared=  .955177, Adjusted R-squared =          .94522 |
| Model test: F[  4,     18] =   95.89,    Prob value =          .00000 |
| Diagnostic: Log-L =    -35.1389, Restricted(b=0) Log-L =     -70.8467 |
|             LogAmemiyaPrCrt.=     .660, Akaike Info. Crt.=      3.490 |
| Autocorrel: Durbin-Watson Statistic =   1.72443,   Rho =       .13779 |
+-----------------------------------------------------------------------+
+-----------------------------------------------------------------------+
| Covariance matrix for the model is adjusted for data clustering.      |
| Sample of     23 observations contained     4 clusters defined by     |
| variable CLASS    which identifies by a value a cluster ID.           |
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant    -3.585879292       1.5875538   -2.259   .0365 le One\post-pre.xl
 PRE          1.517221644   .95635769E-01   15.865   .0000     18.695652
 CLASS1       1.420780437       .43992454    3.230   .0046     .21739130
 CLASS2       1.177398543       .28417486    4.143   .0006     .30434783
 CLASS3       2.954037461   .70132897E-01   42.121   .0000     .26086957
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
le One\post-pre.xls
```

ESTIMATING PROBIT MODELS IN LIMDEP

Often variables need to be transformed or created within a computer program to perform the desired analysis. To demonstrate the process and commands in LIMDEP, start with the Becker and Power's data that have been or can be read into LIMDEP as shown earlier. After reading the data into LIMDEP the first task is to recode the qualitative data into appropriate dummies.

A2 contains a range of values representing various classes of institutions. These are recoded via the "recode" command, where A2 is set equal to 1 for doctoral institutions (100/199), 2 for comprehensive or master's degree granting institutions (200/299), 3 for liberal arts colleges (300/399) and 4 for two-year colleges (400/499) . The "create" command is then used to create 1 and 0 bivariate variables for each of these institutions of post-secondary education:

```
recode; a2; 100/199 = 1; 200/299 = 2; 300/399 = 3; 400/499 =4$
create; doc=a2=1; comp=a2=2; lib=a2=3; twoyr=a2=4$
```

As should be apparent, this syntax says if a2 has a value between 100 and 199 recode it to be 1. If a2 has a value between 200 and 299 recode it to be 2 and so on. Next, create a variable called "doc" and if a2=1, then set doc=1 and for any other value of a2 let doc=0. Create a variable called "comp" and if a2=2, then set comp=1 and for any other value of a2 let comp=0, and so on.

Next 1 - 0 bivariates are created to show whether the instructor had a PhD degree and where the student got a positive score on the postTUCE:

```
create; phd=dj=3; final=cc>0$
```

To allow for quadratic forms in teacher experiences and class size the following variables are created:

```
create; dmsq=dm^2; hbsq=hb^2$
```

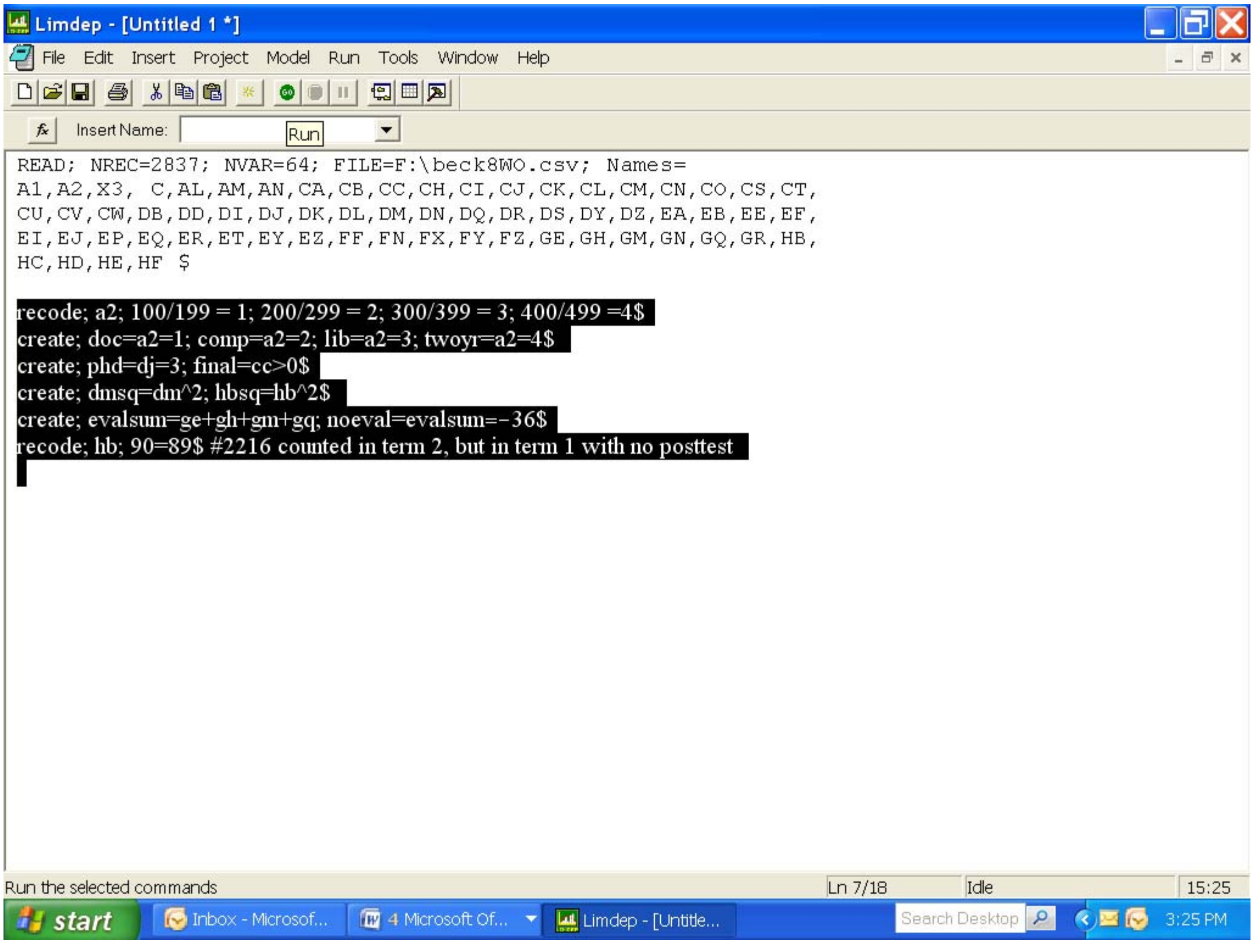
In this data set, as can be seen in the descriptive statistics (DSTAT), all missing values were coded −9. Thus, adding together some of the responses to the student evaluations gives information on whether a student actually completed an evaluation. For example, if the sum of ge, gh, gm, and gq equals −36, we know that the student did not complete a student evaluation in a meaningful way. A dummy variable to reflect this fact is then created by:

```
create; evalsum=ge+gh+gm+gq; noeval=evalsum=−36$
```

Finally, from the TUCE developer it is known that student number 2216 was counted in term 2 but was in term 1 but no postTUCE was taken. This error is corrected with the following command:

```
recode; hb; 90=89$  #2216 counted in term 2, but in term 1 with no posttest
```

These “create” and “recode” commands can be entered into LIMDEP as a block, highlighted and run with the “Go” button. Notice, also, that descriptive statements can be written after the “$” as a reminder or for later justification or reference as to why the command was included.



One of the things of interest to Becker and Powers was whether class size at the beginning or end of the term influenced whether a student completed the postTUCE. This can be assessed by fitting a probit model to the 1 – 0 discrete dependent variable "final." To do this, however, we must make sure that there are no missing data on the variables to be included as regressors. In this data set, all missing values were coded −9. LIMDEP's "reject" command can be employed to remove all records with a −9 value. The "probit" command is used to invoke a maximum likelihood estimation with the following syntax:

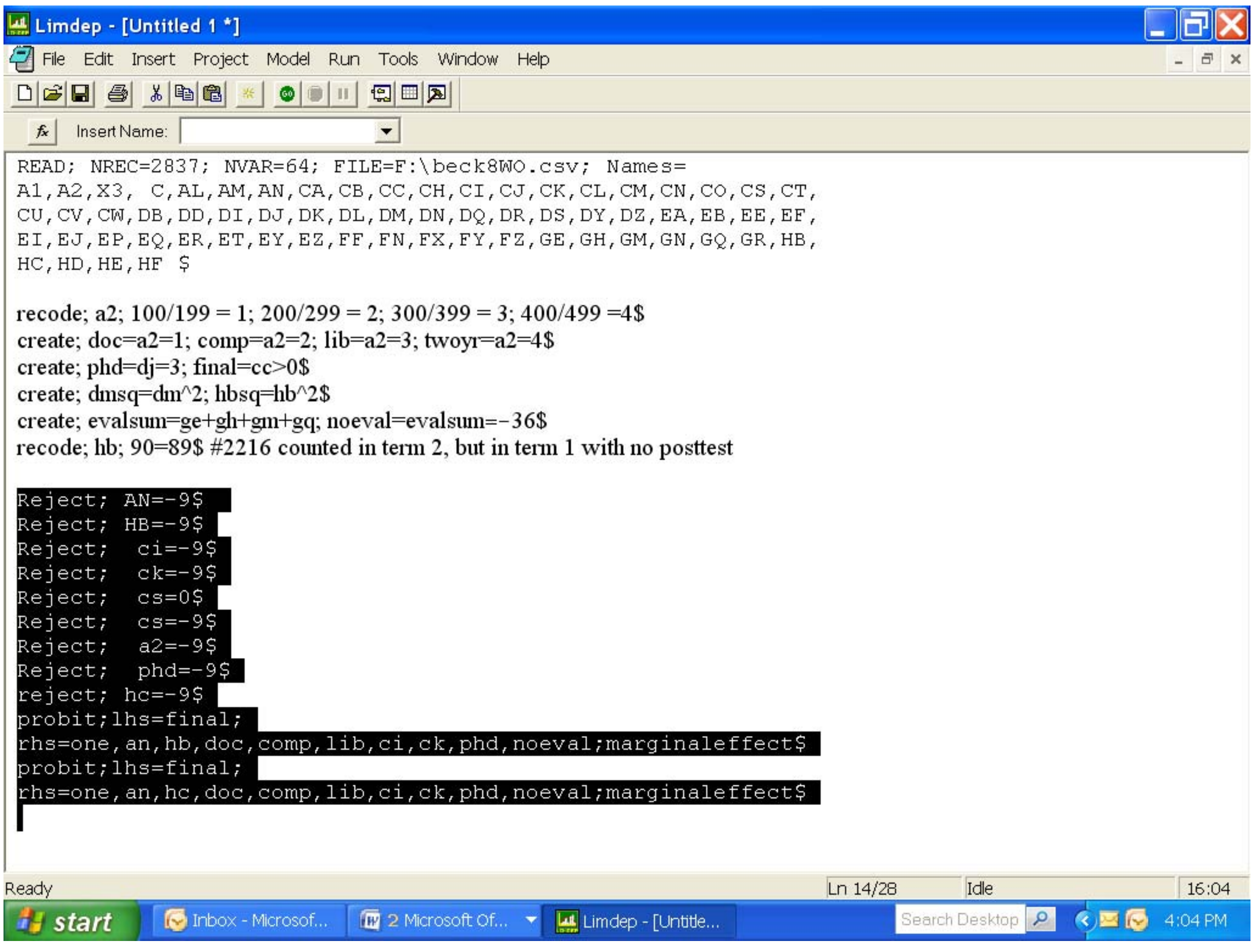
```
Probit; Lhs=???; rhs=one, ???; marginaleffect$
```

where the addition of the "marginaleffect" tells LIMDEP to calculate marginal effects regardless of whether the explanatory variable is or is not continuous. The commands to be entered into the Text/Command Document are then

```
Reject; AN=-9$
Reject; HB=-9$
Reject;  ci=-9$
Reject;  ck=-9$
```

Reject; cs=0$
Reject; cs=-9$
Reject; a2=-9$
Reject; phd=-9$
reject; hc=-9$
probit;lhs=final;
rhs=one,an,hb,doc,comp,lib,ci,ck,phd,noeval;marginaleffect$
probit;lhs=final;
rhs=one,an,hc,doc,comp,lib,ci,ck,phd,noeval;marginaleffect$

which upon highlighting and pressing the Go button yields the output for these two probit models.




```
--> probit;lhs=final;
    rhs=one,an,hb,doc,comp,lib,ci,ck,phd,noeval;marginaleffect$
Normal exit from iterations. Exit status=0.

+---------------------------------------------+
| Binomial Probit Model                       |
```

```
| Maximum Likelihood Estimates                 |
| Model estimated: May 05, 2008 at 04:07:02PM. |
| Dependent variable               FINAL       |
| Weighting variable                None       |
| Number of observations            2587       |
| Iterations completed                 6       |
| Log likelihood function      -822.7411       |
| Restricted log likelihood    -1284.216       |
| Chi squared                   922.9501       |
| Degrees of freedom                   9       |
| Prob[ChiSqd > value] =        .0000000       |
| Hosmer-Lemeshow chi-squared =  26.06658      |
| P-value=  .00102 with deg.fr. =      8       |
+----------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
          Index function for probability
 Constant     .9953497702       .24326247    4.092   .0000
 AN        .2203899720E-01  .94751772E-02    2.326   .0200     10.596830
 HB       -.4882560519E-02  .19241005E-02   -2.538   .0112     55.558949
 DOC          .9757147902       .14636173    6.666   .0000     .31774256
 COMP         .4064945318       .13926507    2.919   .0035     .41785852
 LIB          .5214436028       .17664590    2.952   .0032     .13567839
 CI           .1987315042   .91686501E-01    2.168   .0302     1.2311558
 CK        .8778999306E-01      .13428742     .654   .5133     .91998454
 PHD         -.1335050091       .10303166   -1.296   .1951     .68612292
 NOEVAL      -1.930522400   .72391102E-01  -26.668   .0000     .29068419
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)


+-------------------------------------------+
| Partial derivatives of E[y] = F[*]   with |
| respect to the vector of characteristics. |
| They are computed at the means of the Xs. |
| Observations used for means are All Obs.  |
+-------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
          Index function for probability
 Constant     .1977242134   .48193408E-01    4.103   .0000
 AN        .4378002101E-02  .18769275E-02    2.333   .0197     10.596830
 HB       -.9699107460E-03  .38243741E-03   -2.536   .0112     55.558949
          Marginal effect for dummy variable is P|1 - P|0.
 DOC          .1595047130   .20392136E-01    7.822   .0000     .31774256
          Marginal effect for dummy variable is P|1 - P|0.
 COMP      .7783344522E-01  .25881201E-01    3.007   .0026     .41785852
          Marginal effect for dummy variable is P|1 - P|0.
 LIB       .8208261358E-01  .21451464E-01    3.826   .0001     .13567839
 CI        .3947761030E-01  .18186048E-01    2.171   .0299     1.2311558
          Marginal effect for dummy variable is P|1 - P|0.
 CK        .1820482750E-01  .29016989E-01     .627   .5304     .91998454
          Marginal effect for dummy variable is P|1 - P|0.
 PHD      -.2575430653E-01  .19325466E-01   -1.333   .1826     .68612292
          Marginal effect for dummy variable is P|1 - P|0.
 NOEVAL      -.5339850032   .19586185E-01  -27.263   .0000     .29068419
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+----------------------------------------+
| Fit Measures for Binomial Choice Model |
| Probit   model for variable FINAL      |
+----------------------------------------+
| Proportions P0= .197140   P1= .802860  |
| N =    2587 N0=     510   N1=    2077  |
```

```
| LogL =  -822.74107 LogL0 = -1284.2161  |
| Estrella = 1-(L/L0)^(-2L0/n) = .35729  |
+----------------------------------------+
|     Efron |  McFadden   |  Ben./Lerman |
|    .39635 |    .35934   |       .80562 |
|    Cramer | Veall/Zim.  |     Rsqrd_ML |
|    .38789 |    .52781   |       .30006 |
+----------------------------------------+
| Information  Akaike I.C. Schwarz I.C.  |
| Criteria         .64379    1724.06468  |
+----------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.
Threshold value for predicting Y=1 = .5000
            Predicted
------  ----------  +  -----
Actual     0    1   |  Total
------  ----------  +  -----
  0      342  168   |    510
  1      197 1880   |   2077
------  ----------  +  -----
Total    539 2048   |   2587

--> probit;lhs=final;
    rhs=one,an,hc,doc,comp,lib,ci,ck,phd,noeval;marginaleffect$
Normal exit from iterations. Exit status=0.

+---------------------------------------------+
| Binomial Probit Model                       |
| Maximum Likelihood Estimates                |
| Model estimated: May 05, 2008 at 04:07:03PM.|
| Dependent variable                FINAL     |
| Weighting variable                 None     |
| Number of observations             2587     |
| Iterations completed                  6     |
| Log likelihood function       -825.9472     |
| Restricted log likelihood     -1284.216     |
| Chi squared                    916.5379     |
| Degrees of freedom                    9     |
| Prob[ChiSqd > value] =         .0000000     |
| Hosmer-Lemeshow chi-squared =  22.57308     |
| P-value=  .00396 with deg.fr. =       8     |
+---------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
          Index function for probability
 Constant     .8712666323       .24117408    3.613   .0003
 AN        .2259549490E-01  .94553383E-02    2.390   .0169     10.596830
 HC        .1585898886E-03  .21039762E-02     .075   .9399     49.974874
 DOC          .8804040395       .14866411    5.922   .0000     .31774256
 COMP         .4596088640       .13798168    3.331   .0009     .41785852
 LIB          .5585267697       .17568141    3.179   .0015     .13567839
 CI           .1797199200   .90808055E-01    1.979   .0478     1.2311558
 CK        .1415663447E-01      .13332671     .106   .9154     .91998454
 PHD         -.2351326125       .10107423   -2.326   .0200     .68612292
 NOEVAL      -1.928215642   .72363621E-01  -26.646   .0000     .29068419
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)


+-------------------------------------------+
| Partial derivatives of E[y] = F[*]   with |
| respect to the vector of characteristics. |
| They are computed at the means of the Xs. |
| Observations used for means are All Obs.  |
```

```
+----------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
          Index function for probability
 Constant     .1735365132   .47945637E-01    3.619   .0003
 AN        .4500509092E-02  .18776909E-02    2.397   .0165     10.596830
 HC         .3158750180E-04  .41902052E-03     .075   .9399     49.974874
          Marginal effect for dummy variable is P|1 - P|0.
 DOC          .1467543687   .21319420E-01    6.884   .0000     .31774256
          Marginal effect for dummy variable is P|1 - P|0.
 COMP       .8785901674E-01  .25536388E-01    3.441   .0006     .41785852
          Marginal effect for dummy variable is P|1 - P|0.
 LIB        .8672357482E-01  .20661637E-01    4.197   .0000     .13567839
 CI         .3579612385E-01  .18068050E-01    1.981   .0476     1.2311558
          Marginal effect for dummy variable is P|1 - P|0.
 CK         .2839467767E-02  .26927626E-01     .105   .9160     .91998454
          Marginal effect for dummy variable is P|1 - P|0.
 PHD       -.4448632109E-01  .18193388E-01   -2.445   .0145     .68612292
          Marginal effect for dummy variable is P|1 - P|0.
 NOEVAL      -.5339710749   .19569243E-01  -27.286   .0000     .29068419
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+----------------------------------------+
| Fit Measures for Binomial Choice Model |
| Probit   model for variable FINAL      |
+----------------------------------------+
| Proportions P0= .197140   P1= .802860  |
| N =     2587 N0=     510   N1=    2077  |
| LogL =  -825.94717 LogL0 = -1284.2161  |
| Estrella = 1-(L/L0)^(-2L0/n) = .35481  |
+----------------------------------------+
|     Efron |  McFadden  |  Ben./Lerman  |
|    .39186 |    .35685  |       .80450  |
|    Cramer | Veall/Zim. |      Rsqrd_ML |
|    .38436 |    .52510  |       .29833  |
+----------------------------------------+
| Information  Akaike I.C. Schwarz I.C.  |
| Criteria          .64627    1730.47688  |
+----------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.
Threshold value for predicting Y=1 = .5000
            Predicted
------  ----------  +  -----
Actual      0    1  |  Total
------  ----------  +  -----
  0       337  173  |    510
  1       192 1885  |   2077
------  ----------  +  -----
Total     529 2058  |   2587
```

For each of these two probits, the first block of coefficients are for the latent variable probit equation. The second block provides the marginal effects. The initial class size (hb) probit coefficient −0.004883, however, is highly significant with a two-tail p-value of 0.0112. On the other hand, the end-of-term class size (hc) probit coefficient (0.000159) is insignificant with a two-tail p-value of 0.9399.

The overall goodness of fit can be assessed in several ways. The easiest is the proportion of correct 0 and 1 predictions: For the first probit, using initial class size (hb) as an explanatory variable, the proportion of correct prediction is 0.859 = (342+1880)/2587. For the second probit, using end-of-term class size (hc) as an explanatory variable, the proportion of correct prediction is also 0.859 = (337+1885)/2587. The Chi-square (922.95, df =9) for the probit employing the initial class size is slightly higher than that for the end-of-term probit (916.5379, df =9) but they are both highly significant.

Finally, worth noting when using the “reject” command is that the record is not removed. It can be reactivated with the “include” command. Active and inactive status can be observed in LIMDEP’s editor by the presence or lack of presence of chevrons (>>) next to the row number down the left-hand side of the display.

If you wish to save you work in LIMDEP you must make sure to save each of the files you want separately. Your Text/Command Document, data file, and output files must be saved individually in LIMDEP. There is no global saving of all three files.

CONCLUDING REMARKS

The goal of this hands-on component of this first of four modules was to enable users to get data into LIMDEP, create variables and run regressions on continuous and discrete variables; it was not to explain all of the statistics produced by computer output. For this an intermediate level econometrics textbook (such as Jeffrey Wooldridge, *Introductory Econometrics*) or advanced econometrics textbook such as (William Greene, *Econometric Analysis*) must be consulted.

REFERENCES

Becker, William E. and John Powers (2001). “Student Performance, Attrition, and Class Size Given Missing Student Data,” *Economics of Education Review*, Vol. 20, August: 377-388.

Hilbe, Joseph M. (2006). “A Review of LIMDEP 9.0 and NLOGIT 4.0.” *The American Statistician,* 60(May): 187-202.