Stata Textbook Examples
Applied Regression Analysis by John Fox
Chapter 15: Beyond Linear Least Squares

Section 15. 1 Models for Dichotomous Data

Figure 15.1 on page 440 on data file **chile**.

```
use http://www.ats.ucla.edu/stat/stata/examples/ara/chile, clear
gen voting=1 if (intvote==1)
replace voting = 0 if (intvote==2)

regress voting statquo
predict y, xb

logistic voting statquo
predict pred, p

ksm voting statquo, lowess gen(kp) bwidth(.4) nograph

sort statquo
graph voting y pred kp statquo, jitter(1) connect(.lll) symbol(Oiii)
```

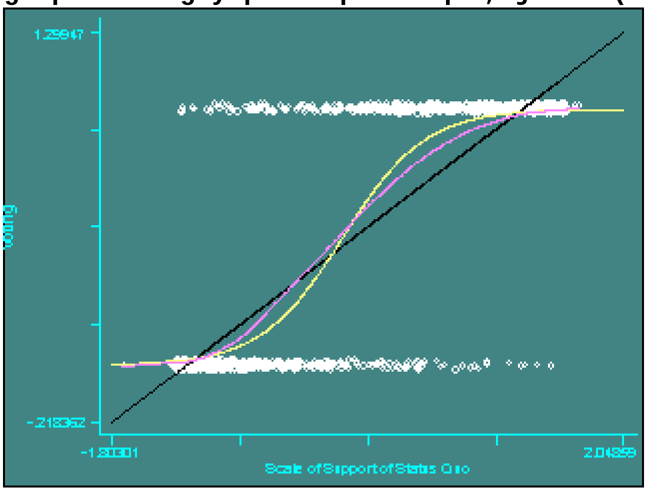


Table 15.1 and 15.2 on page 452 using data file **womenlf**.

```
use http://www.ats.ucla.edu/stat/stata/examples/ara/womenlf, clear

* Generating a new work status variable and an interaction variable

gen ws = 1 if( workstat==1 |  workstat==2)
replace ws=0 if ( workstat==0)
gen ik = husbinc*chilpres

* Contrast between model 1 and 0 is the overall likelihood ratio of
* model 1 and the p-value is the overall Prob > chi2

xi: logistic ws husbinc i.chilpres i.region ik /*model 1 */

(Some output omitted here.)
```

```
Logit estimates                                   Number of obs   =
263
                                                  LR chi2(7)      =
39.61
                                                  Prob > chi2     =
0.0000
Log likelihood = -158.27076                       Pseudo R2       =
0.1112

(More output is omitted.)
```

lrtest, saving(m1)/* saving for further contrast test */

display -2*e(ll) /* displaying deviance */
316.54152

logistic ws /* model 0 */
display -2*e(ll)/* displaying deviance */
356.15089

xi: logistic ws husbinc i.chilpres i.region /* model 2 */
display -2*e(ll)
317.30107

lrtest, saving(m2)
lrtest, using(m1) /* contrast 2-1 */

```
Logistic:  likelihood-ratio test                      chi2(1)     =
0.76
                                                      Prob > chi2 =
0.3835
```

xi: logistic ws husbinc ik i.chilpres /* model 3 */

display -2*e(ll)
319.12422

lrtest, using(m1)/* constrast 3-1 */

```
Logistic:  likelihood-ratio test                      chi2(4)     =
2.58
                                                      Prob > chi2 =
0.6299
```

xi: logistic ws husbinc i.region /* model 4 */
display -2*e(ll)
347.84936

lrtest, using(m2)/* contrast 4-2 */

```
Logistic:  likelihood-ratio test                      chi2(1)     =
30.55
                                                      Prob > chi2 =
0.0000
```

xi: logistic ws i.chilpres i.region /* model 5 */
display -2*e(ll)
322.4267

lrtest, using(m2)/* contrast 5-2 */

```
Logistic:  likelihood-ratio test                      chi2(1)     =
5.13
                                                      Prob > chi2 =
0.0236
```

Figure 15.4 and formula on page 453. In order to add some text to the graph, we borrowed a program from Stata manual called **addtext** (see page 64 of Stata 6 Graphics Manual).

xi: logistic ws i.chilpres husbinc

```
i.chilpres            Ichilp_0-1   (naturally coded; Ichilp_0 omitted)

Logit estimates                                    Number of obs   =
263
                                                   LR chi2(2)      =
36.42
                                                   Prob > chi2     =
0.0000
Log likelihood = -159.86627                        Pseudo R2       =
0.1023

---------------------------------------------------------------------------
---
      ws | Odds Ratio   Std. Err.       z     P>|z|       [95% Conf.
Interval]
---------+-----------------------------------------------------------------
---
Ichilp_1 |   .2068734   .0604614     -5.391   0.000       .1166622
.3668421
 husbinc |   .9585741   .0189607     -2.139   0.032       .9221229
.9964661
---------------------------------------------------------------------------
---
```

logit

```
Logit estimates                                    Number of obs   =
263
                                                   LR chi2(2)      =
36.42
                                                   Prob > chi2     =
0.0000
Log likelihood = -159.86627                        Pseudo R2       =
0.1023

---------------------------------------------------------------------------
---
      ws |      Coef.   Std. Err.       z     P>|z|       [95% Conf.
Interval]
---------+-----------------------------------------------------------------
---
Ichilp_1 |  -1.575648   .2922629     -5.391   0.000      -2.148473   -
1.002824
 husbinc |  -.0423084   .0197801     -2.139   0.032      -.0810767   -
.0035401
   _cons |    1.33583   .3837632      3.481   0.000       .5836677
2.087992
---------------------------------------------------------------------------
---
```

predict pw, p
xi: regress ws i.chilpres husbinc

```
i.chilpres           Ichilp_0-1   (naturally coded; Ichilp_0 omitted)

  Source |       SS       df       MS                  Number of obs =
263
---------+------------------------------               F(  2,   260) =
20.43
   Model |  8.64321054     2  4.32160527               Prob > F      =
0.0000
Residual |  55.0069796   260  .211565306               R-squared     =
0.1358
---------+------------------------------               Adj R-squared =
0.1291
   Total |  63.6501901   262  .242939657               Root MSE      =
.45996

---------------------------------------------------------------------------
---
      ws |      Coef.   Std. Err.       t     P>|t|       [95% Conf.
Interval]
---------+-----------------------------------------------------------------
---
Ichilp_1 |  -.3673736    .061906     -5.934   0.000      -.4892745   -
.2454727
 husbinc |  -.0085375   .0039351     -2.170   0.031      -.0162863   -
.0007887
   _cons |   .7936535   .0766814     10.350   0.000       .6426578
.9446491
---------------------------------------------------------------------------
---
```

```
predict lw, xb
gen pw1=pw if(chilpres==1)
gen pw2=pw if(chilpres==0)
gen lw1=lw if(chilpres==1)
gen lw2=lw if(chilpres==0)
sort husbinc
graph pw1 pw2 lw1 lw2 husbinc, connect(llll) symbol(iiii)
program define addtext, rclass

                       local y1 =.15
                       local x1 =10
                       local y2 =.75
                        local x2 =30

                       gph open
                       graph
                local ay=r(ay)
                local ax=r(ax)
                local by=r(by)
                local bx=r(bx)
                local r1 = `ay'*`y1' + `by'
                local c1 = `ax'*`x1' + `bx'
                local r2 = `ay'*`y2' + `by'
                local c2 = `ax'*`x2' + `bx'
          gph pen 1
          gph text `r1' `c1' 0 0 Children Present
          gph text `r2' `c2' 0 0 Children Absent
          gph close
 end

addtext
```

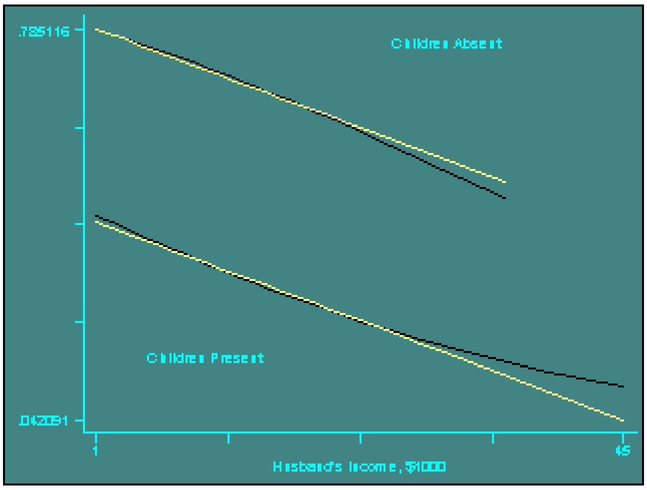


Figure 15.5 on page 459. We can't get the exact lowess smooth as in the book as it needs more than one iterative reweighting steps as there are outliers in the data and Stata's command **ksm** does not have an option on that yet. See the corresponding part of SAS for a better lowess smoothing result.

```
logistic ws chilpres husbinc
predict prob
gen par=(ws-prob)/(prob*(1-prob))-.0423*husbinc /*creating partial
residual*/
ksm par husbinc, lowess bwidth(0.9) gen(kprob) nog /*lowess smoothing*/
reg par husbinc
predict y
graph kprob y par husbinc, connect(ll.) symbol(iiO)
```

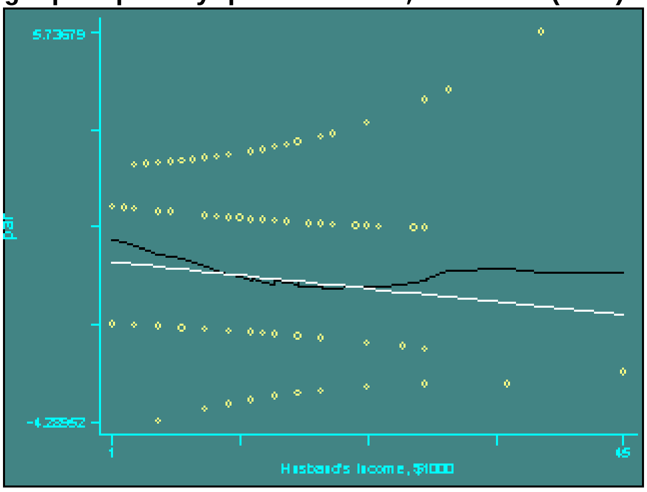


Figure 15.6 on page 461. Notice that in Stata all the diagnostic statistics for logistic regression are adjusted for the number of covariate patterns, so called *m-asymptotic* instead of *n-asymptotic*, i.e., for the number of observations. So we have to do some calculations here in order to get the results in the text book.

```
logistic ws chilpres husbinc
predict yhat /*the predicted value*/
gen pr=(ws-yhat)/sqrt(yhat*(1-yhat)) /* generating Pearson residual on a
case by case basis */
predict myhat, hat
predict pattern, number
egen count=count(obs), by(pattern) /*number of obs sharing a c.p.*/
gen nhat=myhat/count /*hat diagonal on per observation basis*/
gen sr = pr/sqrt(1-nhat)/*studentized pearson residual*/
graph sr nhat, l1(Studentized Residual) ylab(-2(2) 4) yline(-2 0 2) /*
*/ xlab(0(.01) .06) xline(0.0228 .034) b1("Hat-value") b2(" ")
```

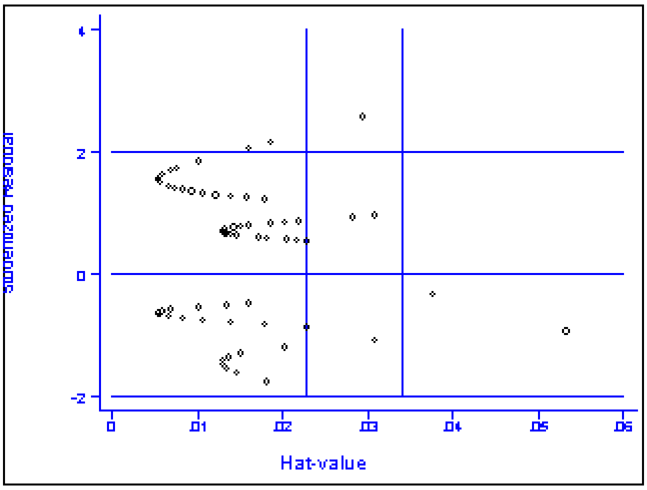
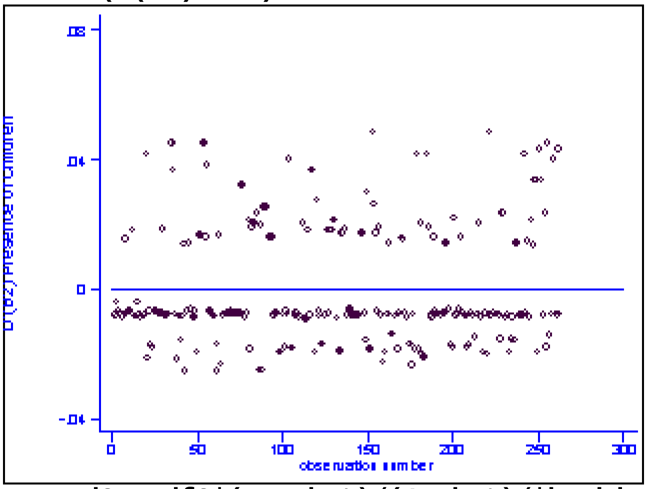
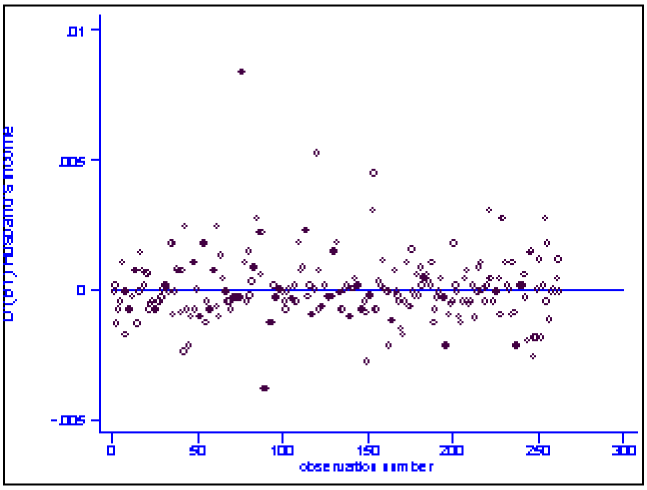


Figure 15.7 (a) and (b) on page 462. Stata does not have built-in command for Dfbeta. We use formula [15.21] to create the required statistics for these figures. This example is continuation of the previous one.

```
gen id=1
set matsize 300
mkmat chilpres husbinc id, matrix(X)
matrix d=e(V)*X'
matrix dt=d'
svmat dt, name(mydf)
gen md1=mydf1*(ws-yhat)/(1-nhat)/*kidDfbeta*/
graph md1 obs, ylab(-0.04(0.04) 0.08) yline(0)l1(D*(B2) Presence of
Children)/*
*/xlab(0(50) 300)
```



```
gen md2=mydf2*(ws-yhat)/(1-nhat)/*husbincDfbeta*/
graph md1 obs, ylab(-0.005(0.005) 0.01) yline(0)l1(D*(B2) Husband's
Income)/*
*/xlab(0(50) 300)
```



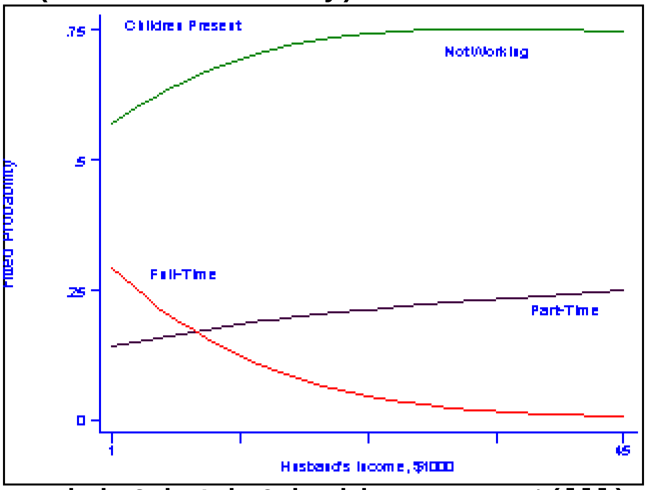
Section 15. 2 Models for Polytomous Data

Calculation and Figure 15.8 on page 468 and 469. We also show how to add text to a graph at the end of this example. Both Figure 15.8 (a) and Figure 15.8 (b) need to run the suitable program **addtext1** to have the text shown.

```
mlogit workstat husbinc chilpre, base(0)

Iteration 0:   log likelihood = -250.24628
Iteration 1:   log likelihood = -214.24438
Iteration 2:   log likelihood =   -211.495
Iteration 3:   log likelihood = -211.44102
Iteration 4:   log likelihood = -211.44096

Multinomial regression                              Number of obs   =
263
                                                    LR chi2(4)      =
77.61
                                                    Prob > chi2     =
0.0000
Log likelihood = -211.44096                         Pseudo R2       =
0.1551

----------------------------------------------------------------------------
---
workstat |      Coef.   Std. Err.       z     P>|z|       [95% Conf.
Interval]
---------+------------------------------------------------------------------
---
parttime |
 husbinc |   .0068921   .0234548      0.294   0.769       -.0390784
.0528627
chilpres |   .0214911   .4690366      0.046   0.963       -.8978037
.940786
   _cons |  -1.432307   .5924623     -2.418   0.016       -2.593512   -
.2711023
---------+------------------------------------------------------------------
---
fulltime |
 husbinc |  -.0972307   .0280958     -3.461   0.001       -.1522975   -
.0421639
chilpres |  -2.558595    .362199     -7.064   0.000       -3.268492   -
1.848698
```

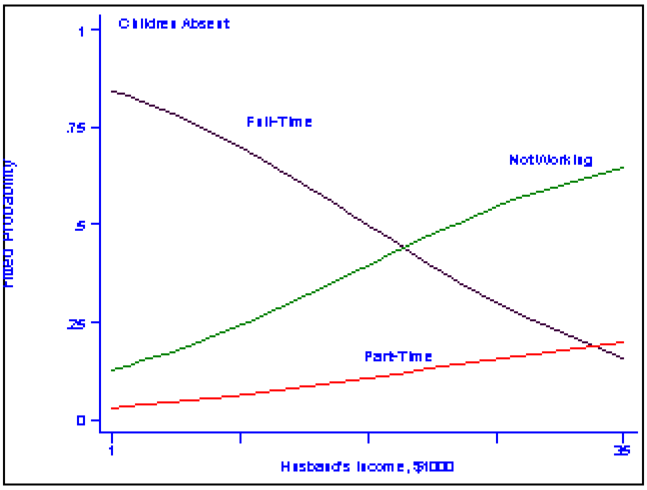
```
    _cons |   1.982822   .4841771      4.095   0.000       1.033853
2.931792
---------------------------------------------------------------------------
---
(Outcome workstat==not work is the comparison group)
```

```
predict p1 if e(sample), outcome(1)
predict p2 if e(sample), outcome(2)
predict p0 if e(sample), outcome(0)
gen kp1=p1 if(chilpres==0)
gen knp1=p1 if (chilpres ==1)
gen kp2=p2 if(chilpres==0)
gen knp2=p2 if(chilpres==1)
gen kp0=p0 if(chilpres==0)
gen knp0 =p0 if(chilpres==1)
sort husbinc

graph knp1 knp2 knp0 husbinc, connect(lll) symbol(iii) ylab(0(.25) .75)
l1(Fitted Probability)
```




```
graph kp2 kp1 kp0 husbinc, connect(lll) symbol(iii) l1(Fitted Probability)
ylab(0(.25) 1)

program define addtext1, rclass
                       local y1 =1
                       local x1 =5
                       local y2 =.75
                       local x2 =12
                       local y3 =.65
                       local x3 =30
                       local y4 =0.15
                       local x4=20

                       gph open
                       graph
                       local ay=r(ay)
                       local ax=r(ax)
                       local by=r(by)
                       local bx=r(bx)

                       local r1 = `ay'*`y1' + `by'
                       local c1 = `ax'*`x1' + `bx'
                       local r2 = `ay'*`y2' + `by'
                       local c2 = `ax'*`x2' + `bx'
                       local r3 = `ay'*`y3' + `by'
                       local c3 = `ax'*`x3' + `bx'
```

```
                        local r4 = `ay'*`y4' + `by'
                        local c4 = `ax'*`x4' + `bx'

        gph pen 1
        gph text `r1' `c1' 0 0 Children Absent
        gph text `r2' `c2' 0 0 Full-Time
        gph text `r3' `c3' 0 0 Not Working
        gph text `r4' `c4' 0 0 Part-Time
        gph close
end

addtext1
```



Calculation on page 473.

```
gen wk=(workstat==0)
logistic wk husbinc chilpres

Logit estimates                                   Number of obs   =
263
                                                  LR chi2(2)      =
36.42
                                                  Prob > chi2     =
0.0000
Log likelihood = -159.86627                       Pseudo R2       =
0.1023

----------------------------------------------------------------------------
---
      wk | Odds Ratio   Std. Err.       z     P>|z|       [95% Conf.
Interval]
---------+------------------------------------------------------------------
---
 husbinc |   1.043216   .0206349      2.139   0.032       1.003546
1.084454
chilpres |   4.833875   1.412762      5.391   0.000       2.725968
8.57176
----------------------------------------------------------------------------
---
logit
Logit estimates                                   Number of obs   =
263
                                                  LR chi2(2)      =
36.42
                                                  Prob > chi2     =
0.0000
```

```
Log likelihood = -159.86627                        Pseudo R2       =
0.1023

---------------------------------------------------------------------------
---
      wk |      Coef.   Std. Err.       z     P>|z|       [95% Conf.
Interval]
---------+-----------------------------------------------------------------
---
 husbinc |   .0423084   .0197801      2.139   0.032       .0035401
.0810767
chilpres |   1.575648   .2922629      5.391   0.000       1.002824
2.148473
   _cons |   -1.33583   .3837632     -3.481   0.000      -2.087992   -
.5836677
---------------------------------------------------------------------------
---
```

lrtest, saving(0)
logistic wk chilpres

```
Logit estimates                                    Number of obs   =
263
                                                   LR chi2(1)      =
31.59
                                                   Prob > chi2     =
0.0000
Log likelihood = -162.27945                        Pseudo R2       =
0.0887

---------------------------------------------------------------------------
---
      wk | Odds Ratio   Std. Err.       z     P>|z|       [95% Conf.
Interval]
---------+-----------------------------------------------------------------
---
chilpres |   4.781119   1.379609      5.422   0.000        2.71589
8.416797
---------------------------------------------------------------------------
---
```

lrtest /*test on the bottom of page 473*/

```
Logistic:  likelihood-ratio test                       chi2(1)     =
4.83
                                                       Prob > chi2 =
0.0280

gen ptime=.
replace ptime = 0 if (workstat==1)
replace ptime=1 if(workstat==2)
logistic ptime husbinc chilpres

Logit estimates                                    Number of obs   =
108
                                                   LR chi2(2)      =
39.85
                                                   Prob > chi2     =
0.0000
Log likelihood = -52.247423                        Pseudo R2       =
0.2761
```

```
------------------------------------------------------------------------------
---
   ptime | Odds Ratio   Std. Err.       z     P>|z|       [95% Conf.
Interval]
---------+--------------------------------------------------------------------
---
 husbinc |    .898285   .0351699     -2.740   0.006       .8319318
.9699305
chilpres |   .0705484   .0381719     -4.900   0.000       .0244301
.2037278
------------------------------------------------------------------------------
---
```

logit

```
Logit estimates                                   Number of obs   =
108
                                                  LR chi2(2)      =
39.85
                                                  Prob > chi2     =
0.0000
Log likelihood = -52.247423                       Pseudo R2       =
0.2761

------------------------------------------------------------------------------
---
   ptime |      Coef.   Std. Err.       z     P>|z|       [95% Conf.
Interval]
---------+--------------------------------------------------------------------
---
 husbinc |  -.1072679   .0391522     -2.740   0.006      -.1840048   -
.0305309
chilpres |  -2.651456   .5410738     -4.900   0.000      -3.711941    -
1.59097
   _cons |   3.477773   .7671069      4.534   0.000       1.974272
4.981275
------------------------------------------------------------------------------
---
```

lrtest, saving(p1)
logistic ptime chilpres

```
Logit estimates                                   Number of obs   =
108
                                                  LR chi2(1)      =
30.87
                                                  Prob > chi2     =
0.0000
Log likelihood = -56.738094                       Pseudo R2       =
0.2138

------------------------------------------------------------------------------
---
   ptime | Odds Ratio   Std. Err.       z     P>|z|       [95% Conf.
Interval]
---------+--------------------------------------------------------------------
---
chilpres |   .0869565     .04288     -4.953   0.000       .0330794
.2285846
------------------------------------------------------------------------------
---
```

```
lrtest, using(p1)/*test on the top of page 474*/

Logistic:  likelihood-ratio test                      chi2(1)     =
8.98
                                                      Prob > chi2 =
0.0027
```

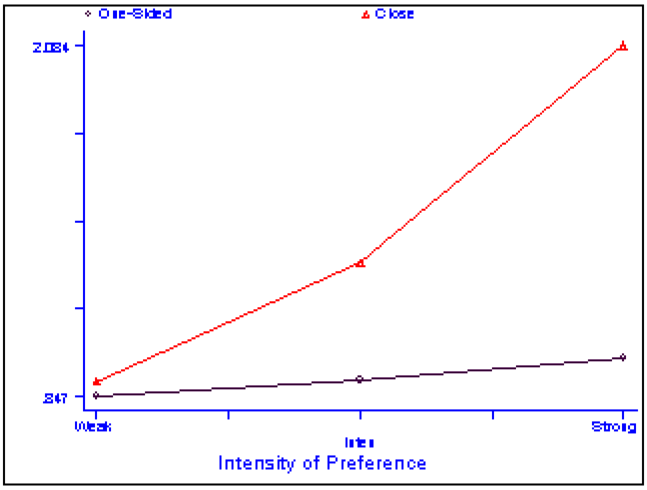
Calculation on page 477.

```
xi: ologit workstat husbinc i.chilpres

i.chilpres            Ichilp_0-1   (naturally coded; Ichilp_0 omitted)

Iteration 0:   log likelihood = -250.24628
Iteration 1:   log likelihood = -221.36758
Iteration 2:   log likelihood = -220.83242
Iteration 3:   log likelihood = -220.83148

Ordered logit estimates                           Number of obs   =
263
                                                  LR chi2(2)      =
58.83
                                                  Prob > chi2     =
0.0000
Log likelihood = -220.83148                       Pseudo R2       =
0.1175

---------------------------------------------------------------------------
---
workstat |      Coef.   Std. Err.       z     P>|z|       [95% Conf.
Interval]
---------+-----------------------------------------------------------------
---
 husbinc |  -.0539007     .01949     -2.766   0.006      -.0921004   -
.0157009
Ichilp_1 |  -1.971957   .2869478     -6.872   0.000      -2.534364    -
1.40955
---------+-----------------------------------------------------------------
---
   _cut1 |  -1.852037   .3862995             (Ancillary parameters)
   _cut2 |  -.9409253   .3699303
---------------------------------------------------------------------------
---
```

Section 15. 3 Discrete Independent Variables and Contingency Tables

The analysis in this section is based on Table 15.3, which is based on data from an example from **The American Voter** (Campbell, et al., 1960). The first data set we create here is based on Table 15.3 for Figure 15.3.

```
input logv1 logvc inten
.847  .9   0
.904 1.318 1
.981 2.084 2
end
label define scale 0 Weak 1 Medium 2 Strong
label values inten scale
label variable logv1 "One-Sided"
label variable logvc "Close"
graph logv1 logvc inten, connect(ll) b1(Intensity of Preference)
```



Now we create another data set below to do the logistic regression and tests over different models. Thus we will have Table 15.4 and Table 15.5 on page 482.

```
input perclose inten1 inten2 voted wv
0 0 0 1 91
0 0 0 0 39
0 1 0 1 121
0 1 0 0 49
0 0 1 1 64
0 0 1 0 24
1 0 0 1 214
1 0 0 0 87
1 1 0 1 284
1 1 0 0 76
1 0 1 1 201
1 0 1 0 25
end

gen  clspref1=perclose*inten1
gen  clspref2=perclose*inten2

logistic voted perclose inten1 inten2 clspref1 clspref2 [fweight=wv]
(Output omitted.)

di -2*e(ll)/*deviance for model 1*/
1356.4343

lrtest, saving(t1)
logistic voted perclose inten1 inten2 [fweight=wv]
(Output omitted.)

di -2*e(ll) /*model 2*/
1363.5529

lrtest, saving(t2)
lrtest, using(t1)/*contrast 2-1*/

Logistic:  likelihood-ratio test                      chi2(2)     =
7.12
                                                      Prob > chi2 =
0.0285

logistic voted perclose clspref1 clspref2 [fweight=wv]
(Output omitted.)

. di -2*e(ll) /*model 3 */
```

```
1356.6253
lrtest, saving(t3)
lrtest, using(t1)/*contrast 3-1 */

Logistic:  likelihood-ratio test                      chi2(2)     =
0.19
                                                      Prob > chi2 =
0.9089

logistic voted inten1 inten2 clspref1 clspref2 [fweight=wv]
(Output omitted.)
di -2*e(ll) /*model 4*/
1356.4869

lrtest, using(t1)

Logistic:  likelihood-ratio test                      chi2(1)     =
0.05
                                                      Prob > chi2 =
0.8186

logistic voted perclose [fweight=wv]
(Output omitted.)

di -2*e(ll) /*model 5 */
1382.6582

lrtest, using(t2)

Logistic:  likelihood-ratio test                      chi2(2)     =
19.11
                                                      Prob > chi2 =
0.0001

logistic voted inten1 inten2 [fweight=wv]
(Output omitted.)

di -2*e(ll) /*model 6*/
1371.8382

lrtest, using(t2)

Logistic:  likelihood-ratio test                      chi2(1)     =
8.29
                                                      Prob > chi2 =
0.0040
```