Model with Discrete Dependent Variables

Probit & Logit Model

The Model

$$I_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \beta_4 x_{4i} + \beta_5 x_{5i} + \varepsilon_i$$

$$P(y_i = 1 | X) = G(I_i)$$

where

Y_i = 1 for the firm that paid dividend and Y_i =0 otherwise

x_{1i} = Retained earning to total equity

x_{2i} = Total equity to total asset

x_{3i} = Return on asset

x_{4i} = Ratio of change in revenue last year to last year total revenue

x_{5i} = Percentile of firm in full distribution of market cap in each year

MLE Estimation

```
. logit y x1 x2 x3 x4 x5, nolog

Logistic regression                                     Number of obs   =       1888
                                                        LR chi2(5)      =    1068.59
                                                        Prob > chi2     =     0.0000
Log likelihood = -757.49946                             Pseudo R2       =     0.4136

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   5.621999   .3310812    16.98   0.000     4.973092    6.270907
          x2 |   1.251322   .3039485     4.12   0.000     .6555939     1.84705
          x3 |   4.945624    1.12468     4.40   0.000     2.741291    7.149957
          x4 |   .3587824   .1571327     2.28   0.022     .0508079     .666757
          x5 |   .7966562    .239171     3.33   0.001     .3278896    1.265423
       _cons |  -1.796861   .2263828    -7.94   0.000    -2.240563   -1.353159
------------------------------------------------------------------------------
Note: 69 failures and 0 successes completely determined.
```

Marginal Effects

```
. mfx

Marginal effects after logit
      y  = Pr(y) (predict)
         =  .01656286
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
      x1 |   .0915741      .01924    4.76   0.000   .053867  .129281  -.638752
      x2 |   .0203822      .00739    2.76   0.006   .005895  .034869   .468602
      x3 |    .080557      .02952    2.73   0.006    .02269  .138424   .050715
      x4 |    .005844      .00292    2.00   0.046   .000112  .011576   .140109
      x5 |   .0129764      .00516    2.52   0.012   .002869  .023083   .522908
------------------------------------------------------------------------------
```

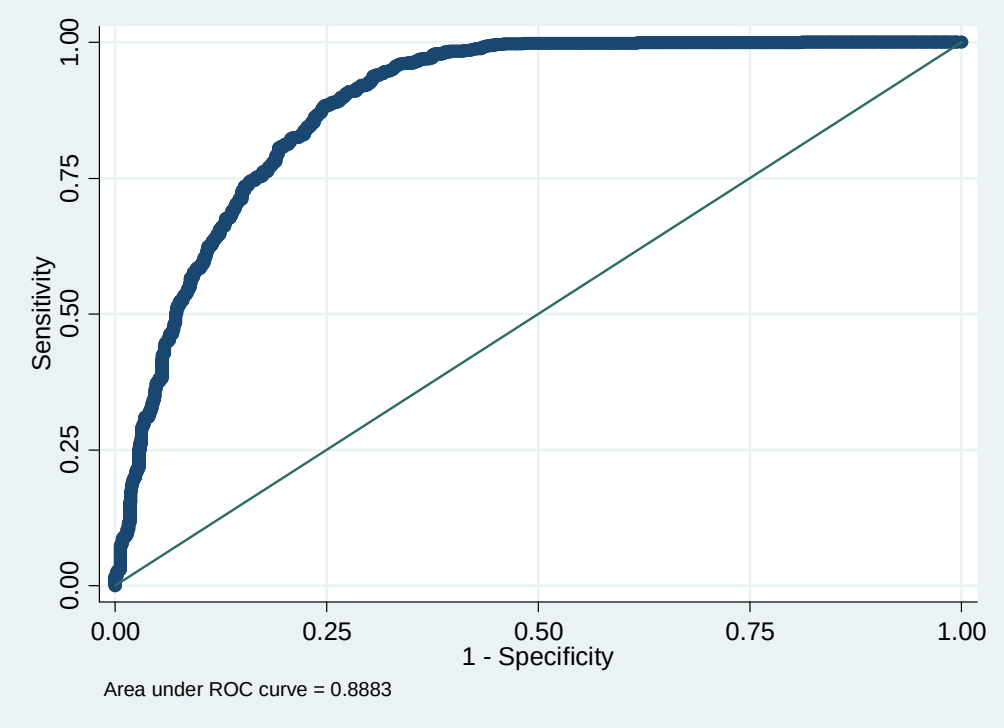
```
. mfx, at(median)

Marginal effects after logit
      y  = Pr(y) (predict)
         =  .62470056
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
      x1 |   1.318076      .07849   16.79   0.000   1.16424  1.47191    .19165
      x2 |   .2933722      .07218    4.06   0.000   .151902  .434842    .45625
      x3 |     1.1595      .26399    4.39   0.000   .642097   1.6769   .044221
      x4 |   .0841165      .03706    2.27   0.023    .01148  .156753    .06545
      x5 |   .1867759      .05599    3.34   0.001   .077031   .29652      .522
------------------------------------------------------------------------------

. mfx, predict(xb)

Marginal effects after logit
      y  = Linear prediction (predict, xb)
         = -4.0838907
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
      x1 |   5.621999      .33108   16.98   0.000   4.97309  6.27091  -.638752
      x2 |   1.251322      .30395    4.12   0.000   .655594  1.84705   .468602
      x3 |   4.945624     1.12468    4.40   0.000   2.74129  7.14996   .050715
      x4 |   .3587824      .15713    2.28   0.022   .050808  .666757   .140109
      x5 |   .7966562      .23917    3.33   0.001    .32789  1.26542   .522908
------------------------------------------------------------------------------

. prchange

logit: Changes in Probabilities for y

    min->max      0->1     -+1/2    -+sd/2  MargEfct
x1    0.9938    0.6149    0.2178    1.0000    0.0916
x2    0.0214    0.0224    0.0216    0.0049    0.0204
x3    0.1218    0.6352    0.1650    0.0068    0.0806
x4    0.9297    0.0067    0.0059    0.0042    0.0058
x5    0.0130    0.0131    0.0133    0.0037    0.0130

             0       1
Pr(y|x)  0.9834  0.0166

              x1        x2        x3        x4        x5
    x=  -.638752   .468602   .050715   .140109   .522908
sd(x)=   10.7594   .238494   .084263   .713799   .288292
```

Statistical Indices

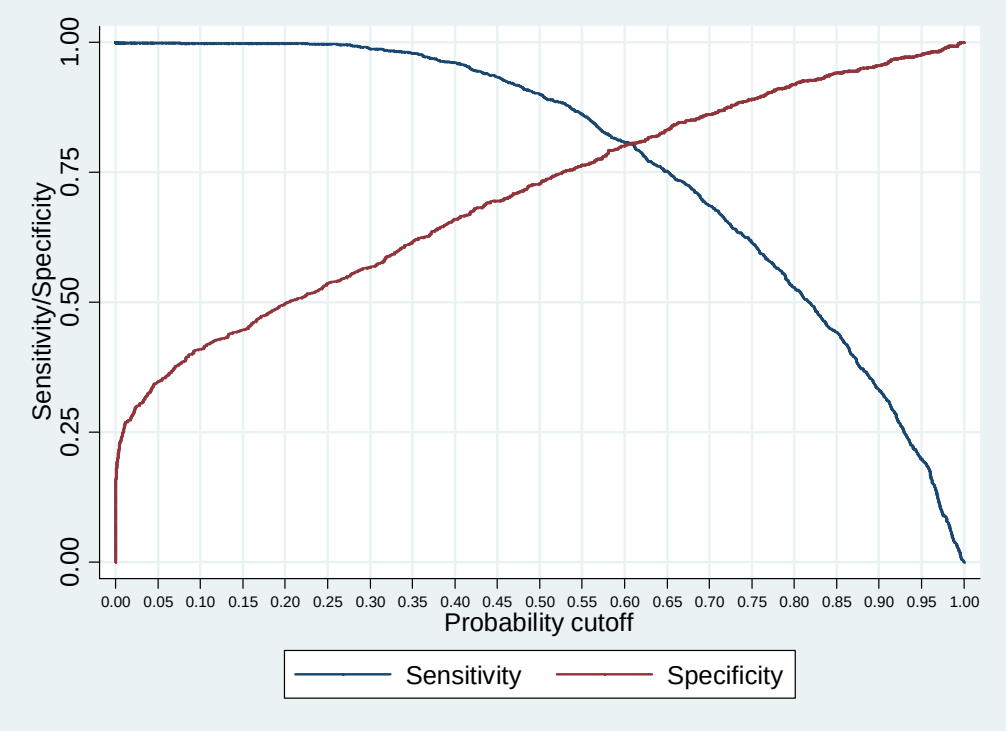
```
. listcoef

logit (N=1888): Factor Change in Odds

  Odds of: 1 vs 0

------------------------------------------------------------------------
           y |      b         z     P>|z|    e^b    e^bStdX      SDofX
-------------+----------------------------------------------------------
          x1 |   5.62200   16.981   0.000 276.4416 1.86e+26    10.7594
          x2 |   1.25132    4.117   0.000   3.4950   1.3477     0.2385
          x3 |   4.94562    4.397   0.000 140.5586   1.5170     0.0843
          x4 |   0.35878    2.283   0.022   1.4316   1.2919     0.7138
          x5 |   0.79666    3.331   0.001   2.2181   1.2582     0.2883
------------------------------------------------------------------------

. fitstat

Measures of Fit for logit of y

Log-Lik Intercept Only:      -1291.794   Log-Lik Full Model:           -757.499
D(1882):                      1514.999   LR(5):                       1068.589
                                         Prob > LR:                      0.000
McFadden's R2:                   0.414   McFadden's Adj R2:              0.409
ML (Cox-Snell) R2:               0.432   Cragg-Uhler(Nagelkerke) R2:     0.580
McKelvey & Zavoina's R2:         0.999   Efron's R2:                     0.490
```

```
Variance of y*:              3675.508   Variance of error:             3.290
Count R2:                       0.827   Adj Count R2:                  0.600
AIC:                            0.809   AIC*n:                      1526.999
BIC:                       -12681.442   BIC':                      -1030.872
BIC used by Stata:           1560.259   AIC used by Stata:          1526.999

. predict pr
(option pr assumed; Pr(y))

. g yhat=0 if pr<=0.5
(1185 missing values generated)

. replace yhat=1 if pr>0.5
(1185 real changes made)

. tabulate y yhat

           |         yhat
         y |         0          1 |     Total
-----------+----------------------+----------
         0 |       597        221 |       818
         1 |       106        964 |     1,070
-----------+----------------------+----------
     Total |       703      1,185 |     1,888

. estat clas

Logistic model for y
              -------- True --------
Classified |         D            ~D  |      Total
-----------+--------------------------+-----------
     +     |       964           221  |       1185
     -     |       106           597  |        703
-----------+--------------------------+-----------
   Total   |      1070           818  |       1888

Classified + if predicted Pr(D) >= .5
True D defined as y != 0
-------------------------------------------------
Sensitivity                     Pr( +| D)   90.09%
Specificity                     Pr( -|~D)   72.98%
Positive predictive value       Pr( D| +)   81.35%
Negative predictive value       Pr(~D| -)   84.92%
-------------------------------------------------
False + rate for true ~D        Pr( +|~D)   27.02%
False - rate for true D         Pr( -| D)    9.91%
False + rate for classified +   Pr(~D| +)   18.65%
False - rate for classified -   Pr( D| -)   15.08%
-------------------------------------------------
Correctly classified                        82.68%
-------------------------------------------------

. lstat
Logistic model for y
              -------- True --------
Classified |         D            ~D  |      Total
-----------+--------------------------+-----------
     +     |       964           221  |       1185
     -     |       106           597  |        703
-----------+--------------------------+-----------
   Total   |      1070           818  |       1888

Classified + if predicted Pr(D) >= .5
True D defined as y != 0
-------------------------------------------------
Sensitivity                     Pr( +| D)   90.09%
Specificity                     Pr( -|~D)   72.98%
Positive predictive value       Pr( D| +)   81.35%
Negative predictive value       Pr(~D| -)   84.92%
-------------------------------------------------
False + rate for true ~D        Pr( +|~D)   27.02%
False - rate for true D         Pr( -| D)    9.91%
False + rate for classified +   Pr(~D| +)   18.65%
False - rate for classified -   Pr( D| -)   15.08%
-------------------------------------------------
Correctly classified                        82.68%
-------------------------------------------------
```

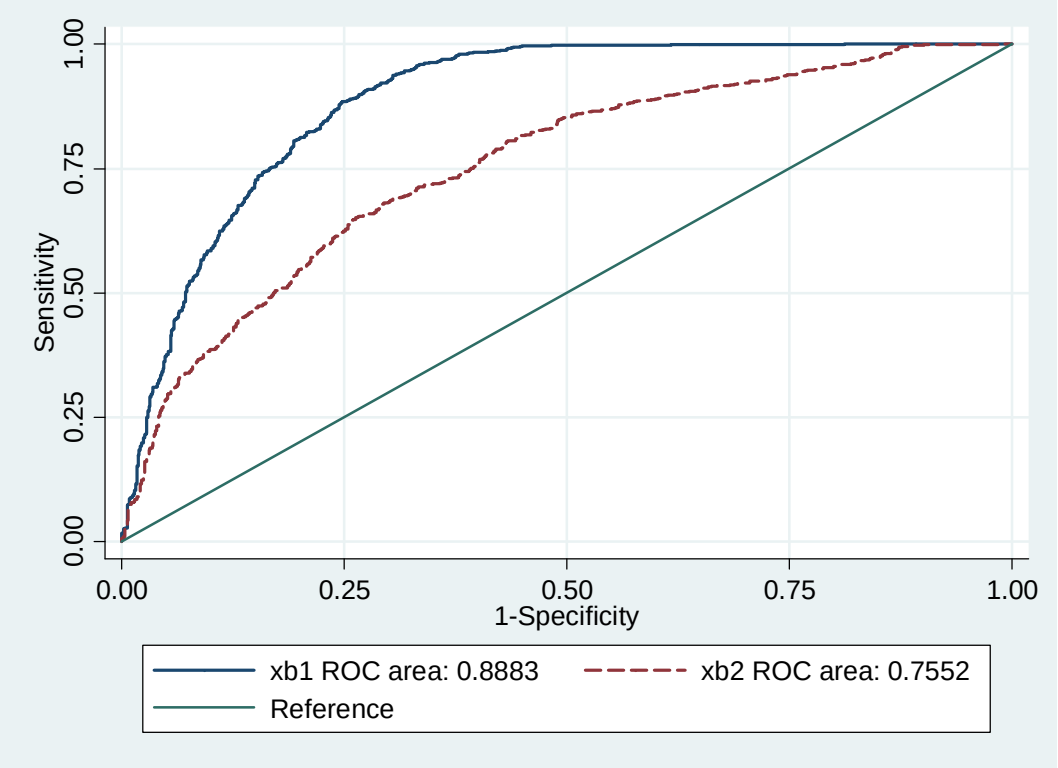
```
. lroc

Logistic model for y

number of observations =      1888
area under ROC curve   =    0.8883
```




```
. predict xb1, xb
(2 missing values generated)

. lsens
```



```
. estat clas, cut(0.606)

Logistic model for y

              -------- True --------
Classified |         D            ~D  |      Total
-----------+--------------------------+-----------
     +     |       862           159  |       1021
     -     |       208           659  |        867
-----------+--------------------------+-----------
   Total   |      1070           818  |       1888

Classified + if predicted Pr(D) >= .606
True D defined as y != 0
--------------------------------------------------
Sensitivity                     Pr( +| D)   80.56%
Specificity                     Pr( -|~D)   80.56%
Positive predictive value       Pr( D| +)   84.43%
Negative predictive value       Pr(~D| -)   76.01%
--------------------------------------------------
False + rate for true ~D        Pr( +|~D)   19.44%
False - rate for true D         Pr( -| D)   19.44%
False + rate for classified +   Pr(~D| +)   15.57%
False - rate for classified -   Pr( D| -)   23.99%
--------------------------------------------------
Correctly classified                        80.56%
--------------------------------------------------

. logit y x2 x3, nolog

Logistic regression                               Number of obs   =       1888
                                                  LR chi2(2)      =     391.38
                                                  Prob > chi2     =     0.0000
Log likelihood =  -1096.105                       Pseudo R2       =     0.1515

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x2 |   2.857145   .2342892    12.19   0.000     2.397946    3.316343
          x3 |   9.131461   .8380706    10.90   0.000     7.488873    10.77405
       _cons |  -1.472011   .1214552   -12.12   0.000    -1.710059   -1.233963
------------------------------------------------------------------------------

. lroc

Logistic model for y

number of observations =     1888
area under ROC curve   =   0.7552

. predict xb2, xb
(2 missing values generated)

. roccomp y xb1 xb2, graph summary

                           ROC                    -Asymptotic Normal--
                  Obs      Area     Std. Err.      [95% Conf. Interval]
-------------------------------------------------------------------------
xb1              1888    0.8883       0.0080        0.87269     0.90399
xb2              1888    0.7552       0.0111        0.73350     0.77695
-------------------------------------------------------------------------
Ho: area(xb1) = area(xb2)
    chi2(1) =   153.61       Prob>chi2 =   0.0000
```



Probit Model

```
. probit y x1 x2 x3 x4 x5, nolog

Probit regression                                 Number of obs   =       1888
                                                  LR chi2(5)      =    1042.01
                                                  Prob > chi2     =     0.0000
Log likelihood = -770.78852                       Pseudo R2       =     0.4033

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   2.991683   .1628704    18.37   0.000     2.672462    3.310903
          x2 |   .6882851   .1742238     3.95   0.000     .3468128    1.029757
          x3 |   2.600306   .5990625     4.34   0.000     1.426165    3.774446
          x4 |   .1802702   .0649368     2.78   0.006     .0529964     .307544
          x5 |   .4506521   .1374255     3.28   0.001     .1813031    .7200011
       _cons |  -.9700784   .1261652    -7.69   0.000    -1.217358   -.7227991
------------------------------------------------------------------------------
Note: 95 failures and 0 successes completely determined.

. mfx

Marginal effects after probit
      y  = Pr(y) (predict)
         =   .0151667
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
      x1 |   .1143775      .02894    3.95   0.000   .057651  .171104  -.638752
      x2 |   .0263144      .01081    2.43   0.015   .005118  .047511   .468602
      x3 |   .0994144      .04073    2.44   0.015   .019592  .179236   .050715
      x4 |   .0068921      .00313    2.21   0.027   .000766  .013018   .140109
      x5 |   .0172292      .00746    2.31   0.021   .002605  .031854   .522908
------------------------------------------------------------------------------

. fitstat

Measures of Fit for probit of y

Log-Lik Intercept Only:      -1291.794   Log-Lik Full Model:           -770.789
D(1882):                      1541.577   LR(5):                       1042.011
```

```
                                            Prob > LR:                        0.000
McFadden's R2:                    0.403   McFadden's Adj R2:                0.399
ML (Cox-Snell) R2:                0.424   Cragg-Uhler(Nagelkerke) R2:       0.569
McKelvey & Zavoina's R2:          0.999   Efron's R2:                       0.483
Variance of y*:                1040.916   Variance of error:                1.000
Count R2:                         0.826   Adj Count R2:                     0.598
AIC:                              0.823   AIC*n:                         1553.577
BIC:                         -12654.863   BIC':                          -1004.294
BIC used by Stata:             1586.837   AIC used by Stata:             1553.577

. lstat

Probit model for y

              -------- True --------
Classified |         D             ~D  |      Total
-----------+--------------------------+-----------
     +     |       963            222  |       1185
     -     |       107            596  |        703
-----------+--------------------------+-----------
   Total   |      1070            818  |       1888

Classified + if predicted Pr(D) >= .5
True D defined as y != 0
--------------------------------------------------
Sensitivity                     Pr( +| D)   90.00%
Specificity                     Pr( -|~D)   72.86%
Positive predictive value       Pr( D| +)   81.27%
Negative predictive value       Pr(~D| -)   84.78%
--------------------------------------------------
False + rate for true ~D        Pr( +|~D)   27.14%
False - rate for true D         Pr( -| D)   10.00%
False + rate for classified +   Pr(~D| +)   18.73%
False - rate for classified -   Pr( D| -)   15.22%
--------------------------------------------------
Correctly classified                        82.57%
--------------------------------------------------
```