

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
```

```
Iteration 0:   log likelihood = -1291.7938
```

```
Iteration 1:   log likelihood = -1081.5633
```

```
...
```

```
Iteration 7:   log likelihood = -757.49946
```

```
Logistic regression
```

```
Number of obs   =      1888
```

```
LR chi2(5)      =    1068.59
```

```
Prob > chi2     =      0.0000
```

```
Pseudo R2      =      0.4136
```

```
Log likelihood = -757.49946
```

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.

Change Convergence value

```
. logit y x1 x2 x3 x4 x5, tol(1e-1)
```

```
Iteration 0:   log likelihood = -1291.7938
```

```
Iteration 1:   log likelihood = -1081.5633
```

```
...
```

```
Iteration 6:   log likelihood = -757.49946
```

```
Logistic regression
```

```
Number of obs   =      1,888
```

```
LR chi2(5)      =    1068.59
```

```
Prob > chi2     =      0.0000
```

```
Pseudo R2      =      0.4136
```

```
Log likelihood = -757.49946
```

y	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
---	-------	-----------	---	------	----------------------

x1	5.621981	.3310802	16.98	0.000	4.973075	6.270886
x2	1.251315	.303948	4.12	0.000	.6555878	1.847042
x3	4.945601	1.124678	4.40	0.000	2.741273	7.149929
x4	.358763	.1571285	2.28	0.022	.0507968	.6667292
x5	.7966555	.2391708	3.33	0.001	.3278895	1.265422
_cons	-1.796851	.2263824	-7.94	0.000	-2.240553	-1.35315

Note: 69 failures and 0 successes completely determined.

Change algorithm from Newton-Raphson to BHHH

```
. logit y x1 x2 x3 x4 x5, tech(bhhh)
```

Iteration 0: log likelihood = -1291.7938

Iteration 1: log likelihood = -1083.2491

...

Iteration 18: log likelihood = -757.49947

Logistic regression	Number of obs	=	1,888
	LR chi2(5)	=	1068.59
	Prob > chi2	=	0.0000
Log likelihood = -757.49947	Pseudo R2	=	0.4136

y	Coef.	OPG Std. Err.	z	P> z	[95% Conf. Interval]	
x1	5.622184	.2989004	18.81	0.000	5.03635	6.208018
x2	1.25141	.306284	4.09	0.000	.6511048	1.851716
x3	4.944747	1.011296	4.89	0.000	2.962643	6.926851
x4	.3594456	.0789519	4.55	0.000	.2047027	.5141885
x5	.7965609	.2415642	3.30	0.001	.3231037	1.270018
_cons	-1.796996	.2192842	-8.19	0.000	-2.226785	-1.367207

Note: 69 failures and 0 successes completely determined.

Change max-iterative time & algorithm from Newton-Raphson to BHHH

```
. logit y x1 x2 x3 x4 x5, iter(5) tech(bhhh)
```

Iteration 0: log likelihood = -1291.7938

Iteration 1: log likelihood = -1083.2491

Iteration 2: log likelihood = -943.13915

Iteration 3: log likelihood = -776.29824

Iteration 4: log likelihood = -759.40564

Iteration 5: log likelihood = -757.7448

convergence not achieved

Logistic regression	Number of obs	=	1,888
	LR chi2(5)	=	1068.10
	Prob > chi2	=	0.0000
Log likelihood = -757.7448	Pseudo R2	=	0.4134

y	Coef.	OPG Std. Err.	z	P> z	[95% Conf. Interval]	
x1	5.596123	.2979084	18.78	0.000	5.012233	6.180013
x2	1.316101	.3068283	4.29	0.000	.7147286	1.917473
x3	5.169074	1.008042	5.13	0.000	3.193348	7.1448
x4	.435926	.0771529	5.65	0.000	.2847091	.587143
x5	.7936992	.2415596	3.29	0.001	.3202511	1.267147
_cons	-1.816599	.2194466	-8.28	0.000	-2.246706	-1.386492

Note: 69 failures and 0 successes completely determined.

Warning: convergence not achieved

Overall Test

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

```
Iteration 0: log likelihood = -1291.7938
```

```
Iteration 1: log likelihood = -1081.5633
```

```
...
```

```
Iteration 7: log likelihood = -757.49946
```

```
Logistic regression
```

```
Number of obs = 1888
```

```
LR chi2(5) = 1068.59
```

```
Prob > chi2 = 0.0000
```

```
Pseudo R2 = 0.4136
```

```
Log likelihood = -757.49946
```

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.

```
. logit y, nolog
```

```
Logistic regression
```

```
Number of obs = 1888
```

```
LR chi2(0) = -0.00
```

```
Prob > chi2 = .
```

```
Pseudo R2 = -0.0000
```

```
Log likelihood = -1291.7938
```

y	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
_cons	.2685516	.0464443	5.78	0.000	.1775224	.3595808

Marginal Effects

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

```
Logistic regression
```

```
Number of obs = 1888
```

```
LR chi2(5) = 1068.59
```

```
Prob > chi2 = 0.0000
```

```
Pseudo R2 = 0.4136
```

```
Log likelihood = -757.49946
```

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.

```
. 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

```
. sum x1 x2 x3 x4 x5
```

variable	Obs	Mean	Std. Dev.	Min	Max
x1	1888	-.6387522	10.75936	-335.5922	.9919
x2	1888	.4686022	.2384942	.0008	.9736
x3	1888	.0507147	.0842626	-.838584	.477435
x4	1888	.140109	.7137989	-1.7647	19.1005
x5	1888	.5229084	.2882922	.008	1

```
. 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, at(0 0 0 0 0)
```

```
Marginal effects after logit
y = Pr(y) (predict)
= .13984246
```

variable	dy/dx	Std. Err.	z	P> z	[95% C.I.]	x
x1	.6731383	.10311	6.53	0.000	.471045 .875232	0
x2	.1583092	.02497	6.34	0.000	.109369 .207249	0
x3	.62177	.15501	4.01	0.000	.317964 .925577	0
x4	.052436	.01221	4.30	0.000	.028508 .076364	0
x5	.0954713	.02347	4.07	0.000	.049467 .141476	0

```
. 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

Statistical Indices

```
. 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
```

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

```
. estat clas
```

Logistic model for y

Classified	True D	~D	Total
+	964	221	1185
-	106	597	703
Total	1070	818	1888

Classified + if predicted $\Pr(D) \geq .5$
True D defined as $y \neq 0$

Sensitivity	$\Pr(+ D)$	90.09%
Specificity	$\Pr(- \sim D)$	72.98%
Positive predictive value	$\Pr(D +)$	81.35%
Negative predictive value	$\Pr(\sim D -)$	84.92%
False + rate for true $\sim D$	$\Pr(+ \sim D)$	27.02%
False - rate for true D	$\Pr(- D)$	9.91%
False + rate for classified +	$\Pr(\sim D +)$	18.65%
False - rate for classified -	$\Pr(D -)$	15.08%
Correctly classified		82.68%

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
Pseudo R2	=	0.4033

Log likelihood = -770.78852

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

```
. estat clas
```

Probit model for y

Classified	True		Total
	D	~D	
+	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%