

### Ordinal Logit and Probit Examples

Below is an example borrowed from Karen Seccombe's project focusing on healthcare among welfare recipients in Oregon. The outcome for this model is a response to a question about how often the respondent cut meal sizes because of affordability, an indicator of food insecurity. Responses to two questions were coded into a single ordinal variable with three values, 0 = never or rarely, 1 = some months but not every month, and 2 = almost every month.

cutmeal how often cut meal size

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 never or rarely	430	67.0	77.9	77.9
	1 some months but not every month	56	8.7	10.1	88.0
	2 almost every month	66	10.3	12.0	100.0
	Total	552	86.0	100.0	
Missing	System	90	14.0		
Total		642	100.0		

### Ordinal Logit Model in SPSS

Regresson → ordinal → options (choose link: Logit)

```
plum cutmeal with mosmed depress1 income educat marital
/link = logit
/print= parameter.
```

### PLUM - Ordinal Regression

Case Processing Summary

		N	Marginal Percentage
cutmeal how often cut meal size	0 never or rarely	280	78.2%
	1 some months but not every month	35	9.8%
	2 almost every month	43	12.0%
Valid		358	100.0%
Missing		284	
Total		642	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	475.710			
Final	449.204	26.506	5	.000

Link function: Logit.

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[cutmeal = 0]	2.465	.505	23.814	1	.000	1.475	3.456
	[cutmeal = 1]	3.233	.521	38.438	1	.000	2.211	4.254
Location	mosmed	.064	.031	4.187	1	.041	.003	.126
	depress1	.208	.049	18.350	1	.000	.113	.303
	income	1.019E-5	1.497E-5	.464	1	.496	-1.914E-5	3.953E-5
	educat	-.049	.146	.114	1	.736	-.335	.237
	marital	.567	.303	3.504	1	.061	-.027	1.160

Link function: Logit.

Probit models in SPSS and SAS can be specified in several different ways. In SPSS, the user can use the *Ordinal* procedure (specifying probit link) or the *Probit* procedure through the menus. The *Probit* procedure requires specification of a variable with the count of total observed, so it is a less convenient approach. SPSS now has a *Generalized Linear Models* option through the menus in which ordinal logistic, probit models, Poisson, and negative binomial models can be tested. In SAS, PROC GENMOD, PROC LOGISTIC (with link=normit or link=probit option), or the Proc Probit can be used. PROC PROBIT also requires a count variable, so I use the PROC LOGISTIC approach.

## Ordered Logit Model in SAS

```
proc logistic descending;
  model cutmeal=mosmed depress1 income educat marital / link=logit expb rsquare;
run;
```

The LOGISTIC Procedure

Model Information	
Data Set	WORK.ONE
Response Variable	CUTMEAL                    how often cut meal size
Number of Response Levels	3
Model	cumulative logit
Optimization Technique	Fisher's scoring
Number of Observations Read	642
Number of Observations Used	358

### Response Profile

Ordered Value	CUTMEAL	Total Frequency
1	2	43
2	1	35
3	0	280

Probabilities modeled are cumulated over the lower Ordered Values.

NOTE: 284 observations were deleted due to missing values for the response or explanatory variables.

### Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

### Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
4.9658	5	0.4201

### Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	486.642	470.136
SC	494.403	497.299
-2 Log L	482.642	456.136

R-Square      0.0714      Max-rescaled R-Square      0.0964

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	26.5064	5	<.0001
Score	26.6980	5	<.0001
Wald	26.8664	5	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq	Exp(Est)
Intercept 2	1	-3.2325	0.5214	38.4382	<.0001	0.039
Intercept 1	1	-2.4655	0.5052	23.8146	<.0001	0.085
MOSMED	1	0.0644	0.0315	4.1878	0.0407	1.067
DEPRESS1	1	0.2080	0.0486	18.3501	<.0001	1.231
INCOME	1	0.000010	0.000015	0.4638	0.4958	1.000
EDUCAT	1	-0.0492	0.1458	0.1138	0.7359	0.952
MARITAL	1	0.5668	0.3027	3.5046	0.0612	1.763

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
MOSMED	1.067	1.003	1.134
DEPRESS1	1.231	1.119	1.354
INCOME	1.000	1.000	1.000
EDUCAT	0.952	0.715	1.267
MARITAL	1.763	0.974	3.190

Association of Predicted Probabilities and Observed Responses

Percent Concordant	66.1	Somers' D	0.331
Percent Discordant	33.1	Gamma	0.333
Percent Tied	0.8	Tau-a	0.121
Pairs	23345	c	0.665

**Probit Model in SPSS**

Regresson → ordinal → options (choose link: Probit)

```
plum cutmeal with mosmed depress1 income educat marital
/link = probit
/print= parameter summary.
```

Case Processing Summary

		N	Marginal Percentage
cutmeal how often cut meal size	0 never or rarely	280	78.2%
	1 some months but not every month	35	9.8%
	2 almost every month	43	12.0%
Valid		358	100.0%
Missing		284	
Total		642	

**Model Fitting Information**

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	475.710			
Final	448.229	27.482	5	.000

Link function: Probit.

**Pseudo R-Square**

Cox and Snell	.074
Nagelkerke	.100
McFadden	.057

Link function: Probit.

**Parameter Estimates**

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[cutmeal = 0]	1.466	.281	27.264	1	.000	.916	2.016
	[cutmeal = 1]	1.895	.287	43.611	1	.000	1.332	2.457
Location	mosmed	.034	.018	3.842	1	.050	1.624E-6	.069
	depress1	.123	.028	18.860	1	.000	.067	.178
	income	5.262E-6	8.641E-6	.371	1	.543	-1.167E-5	2.220E-5
	educat	-.013	.082	.026	1	.872	-.174	.147
	marital	.306	.174	3.107	1	.078	-.034	.647

Link function: Probit.

**Probit Model in SAS**

```
proc logistic descending;
  model cutmeal=mosmed depress1 income educat marital / link=probit stb; /* link=normit is equivalent */
run;
```

The LOGISTIC Procedure

Model Information

Data Set WORK.ONE  
 Response Variable CUTMEAL how often cut meal size  
 Number of Response Levels 3  
 Model cumulative probit  
 Optimization Technique Fisher's scoring

Number of Observations Read 642  
 Number of Observations Used 358

Response Profile

Ordered Value	CUTMEAL	Total Frequency
1	2	43
2	1	35
3	0	280

Probabilities modeled are cumulated over the lower Ordered Values.

NOTE: 284 observations were deleted due to missing values for the response or explanatory variables.

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Score Test for the Equal Slopes Assumption

Chi-Square	DF	Pr > ChiSq
3.2991	5	0.6540

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	486.642	469.160
SC	494.403	496.324
-2 Log L	482.642	455.160

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	27.4818	5	<.0001
Score	29.1289	5	<.0001
Wald	26.9073	5	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq	Standardized Estimate
Intercept 2	1	-1.8945	0.2869	43.6083	<.0001	
Intercept 1	1	-1.4659	0.2807	27.2632	<.0001	
MOSMED	1	0.0344	0.0175	3.8427	0.0500	0.1524
DEPRESS1	1	0.1229	0.0283	18.8598	<.0001	0.3058
INCOME	1	5.266E-6	8.641E-6	0.3714	0.5422	0.0455
EDUCAT	1	-0.0133	0.0820	0.0262	0.8713	-0.0122
MARITAL	1	0.3064	0.1739	3.1057	0.0780	0.1336

Association of Predicted Probabilities and Observed Responses

Percent Concordant	66.0	Somers' D	0.328
Percent Discordant	33.2	Gamma	0.331
Percent Tied	0.8	Tau-a	0.120
Pairs	23345	c	0.664