

## Multinomial logit model

Entering high school students make program choices among general program, vocational program and academic program. Their choice might be modeled using their writing score and their social economic status.

```
. mlogit prog i.ses write, base(1)
```

```
Iteration 0: log likelihood = -204.09667
Iteration 1: log likelihood = -180.80105
Iteration 2: log likelihood = -179.98724
Iteration 3: log likelihood = -179.98173
Iteration 4: log likelihood = -179.98173
```

```
Multinomial logistic regression      Number of obs   =      200
                                      LR chi2(6)       =      48.23
                                      Prob > chi2      =      0.0000
Log likelihood = -179.98173          Pseudo R2       =      0.1182
```

prog	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
general	(base outcome)					
academic						
ses						
2	.533291	.4437321	1.20	0.229	-.336408 1.40299	
3	1.162832	.5142195	2.26	0.024	.1549804 2.170684	
write	.0579284	.0214109	2.71	0.007	.0159637 .0998931	
_cons	-2.852186	1.166439	-2.45	0.014	-5.138365 -.5660075	
vocation						
ses						
2	.8246841	.4901229	1.68	0.092	-.1359392 1.785307	
3	.1801617	.648455	0.28	0.781	-1.090787 1.45111	
write	-.0556742	.0233313	-2.39	0.017	-.1014028 -.0099456	
_cons	2.366014	1.174248	2.01	0.044	.0645293 4.667498	

$$\ln\left(\frac{P(\text{prog} = \text{academic})}{P(\text{prog} = \text{general})}\right) = -2.85 + 0.53(\text{ses} = 2) + 1.16(\text{ses} = 3) + 0.058 * \text{write}$$

$$\ln\left(\frac{P(\text{prog} = \text{vocation})}{P(\text{prog} = \text{general})}\right) = 2.37 + 0.82(\text{ses} = 2) + 0.18(\text{ses} = 3) - 0.056 * \text{write}$$

- A one-unit increase in writing score is associated with 0.058 increases in the relative log odds of being academic program vs. general program

- A one-unit increase in writing score is associated with 0.056 decreases in the relative log odds of being vocation program vs. general program

*Roughly interpretation:* if writing score is higher, students are likely to enter into academic program, but less likely to enter into vocational program, compared to general program as a based case.

- The relative log odds of being in academic program vs. in general program will increase by 1.163 if moving from the lowest level of ses (ses=1) to the highest level of ses (ses=3)

The ratio of the probability of choosing one outcome category over the probability of choosing the baseline category is often referred to as **relative risk** (odds ratio):

$$\frac{P(y_i=j)}{P(y_i=1)} = \exp(x_i\beta_j)$$

. mlogit, rrr

```
Multinomial logistic regression      Number of obs   =      200
                                      LR chi2(6)       =      48.23
                                      Prob > chi2      =      0.0000
Log likelihood = -179.98173          Pseudo R2       =      0.1182
```

prog	RRR	Std. Err.	z	P> z	[95% Conf. Interval]	
general	(base outcome)					
-----						
academic						
ses						
2	1.704533	.7563559	1.20	0.229	.7143316	4.067343
3	3.19898	1.644978	2.26	0.024	1.167635	8.764273
write	1.059639	.0226879	2.71	0.007	1.016092	1.105053
_cons	.057718	.0673245	-2.45	0.014	.0058673	.5677878
-----						
vocation						
ses						
2	2.28116	1.118049	1.68	0.092	.8728957	5.961412
3	1.197411	.7764672	0.28	0.781	.3359521	4.26785
write	.9458472	.0220679	-2.39	0.017	.903569	.9901037
_cons	10.65484	12.51142	2.01	0.044	1.066657	106.4312
-----						

The relative risk ratio for a one-unit increase in writing score is 1.06 [=exp(0.058)] for being in academic program vs. general program

→ prob(prog=academic) = 1.06\* prob(prog=general)

We also have prob(prog=vocation) = 0.95\*prob(prog=general)

- Comparing between the highest and the lowest ses, we have

prob(prog=academic) = 3.20\* prob(prog=general), and

prob(prog=vocation) = 1.20\*prob(prog=general)

*Roughly interpretation:* With highest socio-economic status, students are likely to enter into academic program more than enter into vocational program, but still, students with highest socio-economic status have more possibility to enter into these two programs than enter into general program.

Moreover, if the students are middle-class, they are likely to enter into vocational school.

Note: Better use average marginal effects to finalize your conclusions

Or, we can test hypotheses:

```
test [academic]3.ses = [vocation]3.ses
```

```
( 1) [academic]3.ses - [vocation]3.ses = 0
```

```
      chi2( 1) =    2.72  
      Prob > chi2 =  0.0989
```

```
test [academic]2.ses = [vocation]2.ses
```

```
( 1) [academic]2.ses - [vocation]2.ses = 0
```

```
      chi2( 1) =    0.37  
      Prob > chi2 =  0.5407
```

Testing whether the overall effect of **ses** is statistically significant

```
test 2.ses 3.ses
```

```
( 1) [general]2o.ses = 0  
( 2) [academic]2.ses = 0  
( 3) [vocation]2.ses = 0  
( 4) [general]3o.ses = 0  
( 5) [academic]3.ses = 0  
( 6) [vocation]3.ses = 0
```

```
Constraint 1 dropped  
Constraint 4 dropped
```

```
      chi2( 4) =   10.82  
      Prob > chi2 =  0.0287
```

To evaluate predicted probability outcome:

```
margins ses, atmeans predict(outcome(1))
```

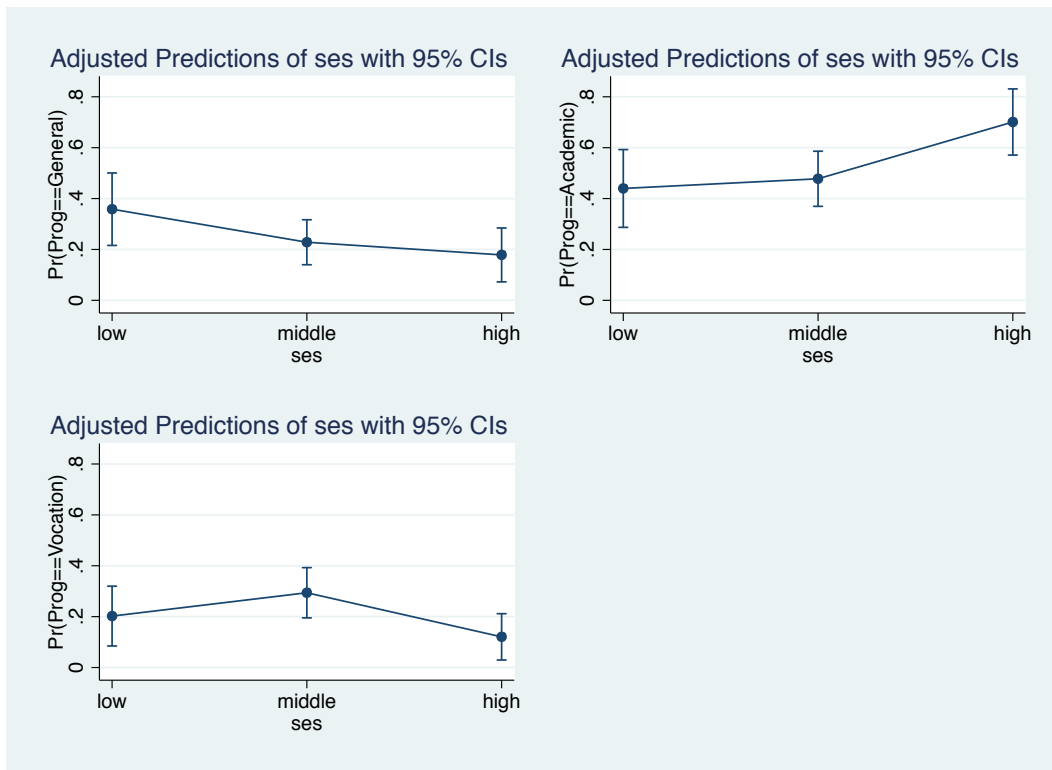
```
Adjusted predictions          Number of obs   =          200  
Model VCE      : OIM
```

```
Expression   : Pr(prog==general), predict(outcome(1))  
at           : 1.ses      =      .235 (mean)  
              2.ses      =      .475 (mean)  
              3.ses      =      .29 (mean)  
              write      =     52.775 (mean)
```

	Margin	Delta-method Std. Err.	z	P> z	[95% Conf. Interval]	
ses						
1	.3581927	.0726423	4.93	0.000	.2158163	.500569
2	.2283338	.0451162	5.06	0.000	.1399075	.31676
3	.1784932	.0540486	3.30	0.001	.0725598	.2844266

Do marginal effects for each outcome!

Here is the graph for comparison (use `marginsplot, name(general)` after `margins` command)



## Marginal effects

margins, dydx(\*) predict(outcome(2))

Average marginal effects  
Model VCE : OIM

Number of obs = 200

Expression : Pr(prog==academic), predict(outcome(2))  
dy/dx w.r.t. : 2.ses 3.ses write

	dy/dx	Delta-method Std. Err.	z	P> z	[95% Conf. Interval]	
ses						
2	.0357643	.0840571	0.43	0.670	-.1289847	.2005133
3	.2318097	.0936665	2.47	0.013	.0482267	.4153928
write	.0171412	.0028768	5.96	0.000	.0115028	.0227796

Note: dy/dx for factor levels is the discrete change from the base level.

## Comparing verage marginal effects

	y1 b/se	y2 b/se	y3 b/se
2.ses	-0.1245 (0.0799)	0.0358 (0.0841)	0.0887 (0.0698)
3.ses	-0.1601* (0.0869)	0.2318** (0.0937)	-0.0718 (0.0743)
write	-0.0028 (0.0028)	0.0171*** (0.0029)	-0.0143*** (0.0025)

## Ordered outcome

tab apply

apply	Freq.	Percent	Cum.
unlikely	220	55.00	55.00
somewhat likely	140	35.00	90.00
very likely	40	10.00	100.00
Total	400	100.00	

ologit apply pared public gpa

Iteration 4: log likelihood = -358.51244

Ordered logistic regression	Number of obs	=	400
	LR chi2(3)	=	24.18
	Prob > chi2	=	0.0000
Log likelihood = -358.51244	Pseudo R2	=	0.0326

apply	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
pared	1.047664	.2657891	3.94	0.000	.5267266 1.568601
public	-.0586828	.2978588	-0.20	0.844	-.6424754 .5251098
gpa	.6157458	.2606311	2.36	0.018	.1049183 1.126573
/cut1	2.203323	.7795353			.6754621 3.731184
/cut2	4.298767	.8043147			2.72234 5.875195

- If at least one parent has a graduate degree, we expect a 1.05 increase in the log odds of being in a higher level of **apply**, given all of the other variables in the model are held constant.

- For a one unit increase in **gpa**, we would expect a 0.62 increase in the log odds of being in a higher level of **apply**, given that all of the other variables in the model are held constant.

The cutpoints shown at the bottom of the output indicate where the latent variable is cut to make the three groups that we observe in our data.

### Average marginal effects:

. margins, dydx(\*) predict(outcome(0))

Average marginal effects	Number of obs	=	400
Expression : Pr(apply==0), predict(outcome(0))			
dy/dx w.r.t. : pared public gpa			

	dy/dx	Delta-method Std. Err.	z	P> z	[95% Conf. Interval]
pared	-.2453203	.0583121	-4.21	0.000	-.3596099 -.1310308
public	.0137411	.0697304	0.20	0.844	-.1229279 .1504101
gpa	-.1441827	.0594591	-2.42	0.015	-.2607203 -.0276451

The probability of unlikely applying to graduate school decreases if at least one parent has a graduate degree.