

Logit, Probit, and Multinomial Logit models in R

(v. 3.5)

Oscar Torres-Reyna
otorres@princeton.edu

If outcome or dependent variable is binary and in the form 0/1, then use logit or probit models.

Some examples are:

Did you vote in the last election?

0 'No'

1 'Yes'

Do you prefer to use public transportation or to drive a car?

0 'Prefer to drive'

1 'Prefer public transport'

If outcome or dependent variable is categorical but are ordered (i.e. low to high), then use ordered logit or ordered probit models. Some examples are:

Do you agree or disagree with the President?

1 'Disagree'

2 'Neutral'

3 'Agree'

What is your socioeconomic status?

1 'Low'

2 'Middle'

3 'High'

If outcome or dependent variable is categorical without any particular order, then use multinomial logit. Some examples are:

If elections were held today, for which party would you vote?

1 'Democrats'

2 'Independent'

3 'Republicans'

What do you like to do on the weekends?

1 'Rest'

2 'Go to movies'

3 'Exercise'

Logit model

Getting sample data

```
library(foreign)
mydata <- read.dta("https://dss.princeton.edu/training/Panel101.dta")
```

Running a logit model

```
logit <- glm(y_bin ~ x1 + x2 + x3, family=binomial(link="logit"), data=mydata)
```

Store results

Outcome

Predictors

Type of model

Data source

```
summary(logit)
```

Call:

```
glm(formula = y_bin ~ x1 + x2 + x3, family = binomial(link = "logit"),
    data = mydata)
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-2.0277	0.2347	0.5542	0.7016	1.0839

Coefficients:

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	0.4262	0.6390	0.667	0.5048
x1	0.8618	0.7840	1.099	0.2717
x2	0.3665	0.3082	1.189	0.2343
x3	0.7512	0.4548	1.652	0.0986 .

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 70.056 on 69 degrees of freedom
Residual deviance: 65.512 on 66 degrees of freedom
AIC: 73.512

Number of Fisher Scoring iterations: 5

The **Pr(>|z|)** column shows the two-tailed p-values testing the null hypothesis that the coefficient is equal to zero (i.e. no significant effect). The usual value is 0.05, by this measure none of the coefficients have a significant effect on the log-odds ratio of the dependent variable. The coefficient for x3 is significant at 10% (<0.10).

The **z value** also tests the null that the coefficient is equal to zero. For a 5% significance, the z-value should fall outside the ± 1.96 .

The **Estimate** column shows the coefficients in log-odds form. When x3 increase by one unit, the expected change in the log odds is 0.7512. What you get from this column is whether the effect of the predictors is positive or negative. See next page for an extended explanation.

Logit model

The `stargazer()` function from the package `-stargazer` allows a publication quality of the logit model.

The model will be saved in the working directory under the name `'logit.htm'` which you can open with Word or any other word processor.

```
library(stargazer)
stargazer(logit, type="html", out="logit.htm")
```

	<i>Dependent variable:</i>
	y_bin
x1	0.862 (0.784)
x2	0.367 (0.308)
x3	0.751* (0.455)
Constant	0.426 (0.639)
Observations	70
Log Likelihood	-32.756
Akaike Inf. Crit.	73.512
Note:	*p**p***p<0.01

NOTE: Use the option `type = "text"` if you want to see the results directly in the RStudio console.

Logit model: odds ratio

Odds ratio interpretation (OR): Based on the output below, when x_3 increases by one unit, the odds of $y = 1$ increase by 112% $-(2.12-1)*100$ -. Or, the odds of $y=1$ are 2.12 times higher when x_3 increases by one unit (keeping all other predictors constant). To get the odds ratio, you need exponentiate the logit coefficient.

Estimating the odds ratio by hand

```
cbind(Estimate=round(coef(logit),4),  
      OR=round(exp(coef(logit)),4))
```

	Estimate	OR
(Intercept)	0.4262	1.5314
x1	0.8618	2.3674
x2	0.3665	1.4427
x3	0.7512	2.1196

The **Estimate** column shows the coefficients in log-odds form. When x_3 increase by one unit, the expected change in the log odds is 0.7512. Lets hold x_1 and x_2 constant at their means, and vary x_3 with values 1, 2, and 3, to get the predicted log-odds given each of the three values of x_3 :

```
r1 <- logit$coeff[1] + logit$coeff[2]*mean(mydata$x1) +  
      logit$coeff[3]*mean(mydata$x2) +  
      logit$coeff[4]*1  
> r1  
1.784902  
  
r2 <- logit$coeff[1] + logit$coeff[2]*mean(mydata$x1) +  
      logit$coeff[3]*mean(mydata$x2) +  
      logit$coeff[4]*2  
> r2  
2.536113  
  
r3 <- logit$coeff[1] + logit$coeff[2]*mean(mydata$x1) +  
      logit$coeff[3]*mean(mydata$x2) +  
      logit$coeff[4]*3  
> r3  
3.287325
```

Using package --mfx--

```
library(mfx)  
logitor(y_bin ~ x1 + x2 + x3, data=mydata)  
Call:  
logitor(formula = y_bin ~ x1 + x2 + x3, data = mydata)  
  
Odds Ratio:  
      OddsRatio Std. Err.      z    P>|z|  
x1    2.36735    1.85600  1.0992  0.27168  
x2    1.44273    0.44459  1.1894  0.23427  
x3    2.11957    0.96405  1.6516  0.09861 .  
---  
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

When x_3 increases from 1 to 2, the log-odds increases:

```
r2-r1  
0.7512115
```

When x_3 increases from 2 to 3, the log-odds increases:

```
r3-r2  
0.7512115
```

Which corresponds to the estimate for x_3 above.

The odds ratio, is the exponentiation of the difference of the log-odds

```
> exp(r2-r1)  
2.119566
```

Or, the ratio of the exponentiation of each of the log-odds.

```
> exp(r2)/exp(r1)  
2.119566
```

OTR Which corresponds to the OR value for x_3 above. 5

Logit model: odds ratios

Relative risk ratios allow an easier interpretation of the logit coefficients. They are the exponentiated value of the logit coefficients.

```
logit.or = exp(coef(logit))
```

```
logit.or
```

```
(Intercept)          x1          x2          x3
      1.531417      2.367352      1.442727      2.119566
```

```
library(stargazer)
```

```
stargazer(logit, type="html", coef=list(logit.or), p.auto=FALSE, out="logitor.htm")
```

<i>Dependent variable:</i>	
	<i>y_bin</i>
x1	2.367 (0.784)
x2	1.443 (0.308)
x3	2.120* (0.455)
Constant	1.531 (0.639)
Observations	70
Log Likelihood	-32.756
Akaike Inf. Crit.	73.512
Note:	*p**p***p<0.01

Keeping all other variables constant, when x1 increases one unit, it is 2.367 times more likely to be in the 1 category. In other words, the odds of being in the 1 category (as opposed to the 0 category) are 136% higher when x1 move one unit ($2.36 - 1$). The coefficient, however, is not significant.

NOTE: Use the option `type = "text"` if you want to see the results directly in the RStudio console.

Logit model: predicted probabilities

The logit model can be written as (Gelman and Hill, 2007):

$$\Pr(y_i = 1) = \text{Logit}^{-1}(X_i\beta)$$

In the example:

```
logit <- glm(y_bin ~ x1 + x2 + x3, family=binomial(link="logit"), data=mydata)
```

```
coef(logit)
```

(Intercept)	x1	x2	x3
0.4261935	0.8617722	0.3665348	0.7512115

$$\Pr(y_i = 1) = \text{Logit}^{-1}(0.4261935 + 0.8617722*x1 + 0.3665348*x2 + 0.7512115*x3)$$

Estimating the probability at the mean point of each predictor can be done by inverting the logit model. Gelman and Hill provide a function for this (p. 81), also available in the R package `-arm-`

```
invlogit = function (x) {1/(1+exp(-x))}  
invlogit(coef(logit)[1]+  
         coef(logit)[2]*mean(mydata$x1)+  
         coef(logit)[3]*mean(mydata$x2)+  
         coef(logit)[4]*mean(mydata$x3))
```

$$\Pr(y_i = 1) = 0.8328555$$

Logit model: predicted probabilities

Adding categorical variable, the model would be:

```
logit.cat <- glm(y_bin ~ x1 + x2 + x3 + opinion,
                 family=binomial(link="logit"), data=mydata)

coef(logit.cat)
      (Intercept)           x1           x2           x3  opinionAgree  opinionDisag opinionStr disag
      0.8816118      1.1335562      0.3021217      0.3976276      -1.9163569      0.3270627      0.6891686
```

Estimating the probability when opinion = 'Agree'

```
invlogit = function (x) {1/(1+exp(-x))}
```

```
invlogit(coef(logit.cat)[1]+
         coef(logit.cat)[2]*mean(mydata$x1)+
         coef(logit.cat)[3]*mean(mydata$x2)+
         coef(logit.cat)[4]*mean(mydata$x3)+
         coef(logit.cat)[5]*1)
```

$\Pr(y_i = 1 \mid \text{opinion} = \text{"Agree"}) = 0.5107928$

Logit model: predicted probabilities

```
invlogit = function (x) {1/(1+exp(-x))}
```

Estimating the probability when opinion = **'Disagree'**

```
invlogit(coef(logit.cat)[1]+  
         coef(logit.cat)[2]*mean(mydata$x1)+  
         coef(logit.cat)[3]*mean(mydata$x2)+  
         coef(logit.cat)[4]*mean(mydata$x3)+  
         coef(logit.cat)[6]*1)
```

```
Pr( $y_i = 1$  | opinion= "Disagree") = 0.9077609
```

Estimating the probability when opinion = **'Strongly disagree'**

```
invlogit(coef(logit.cat)[1]+  
         coef(logit.cat)[2]*mean(mydata$x1)+  
         coef(logit.cat)[3]*mean(mydata$x2)+  
         coef(logit.cat)[4]*mean(mydata$x3)+  
         coef(logit.cat)[7]*1)
```

```
Pr( $y_i = 1$  | opinion= "Strongly disagree") = 0.933931
```

Estimating the probability when opinion = **'Strongly agree'**

```
invlogit(coef(logit.cat)[1]+  
         coef(logit.cat)[2]*mean(mydata$x1)+  
         coef(logit.cat)[3]*mean(mydata$x2)+  
         coef(logit.cat)[4]*mean(mydata$x3))
```

```
Pr( $y_i = 1$  | opinion= "Strongly agree") = 0.8764826
```

Logit model: predicted probabilities

Another way to estimate the predicted probabilities is by setting initial conditions.

Getting predicted probabilities holding all predictors or independent variables to their means.

```
allmean <- data.frame(x1=mean(mydata$x1),  
                      x2=mean(mydata$x2),  
                      x3=mean(mydata$x3))
```

Creating a new dataset with
the mean values of the
predictors

```
allmean  
      x1      x2      x3  
1 0.6480006 0.1338694 0.761851
```

After estimating the logit model and creating the dataset with the mean values of the predictors, you can use the `predict()` function to estimate the predicted probabilities (for help/details type `?predict.glm`), and add them to the `allmean` dataset.

```
allmean$pred.prob <- predict(logit, newdata=allmean, type="response")
```

The object with the
logit coefficients

Dataset with the
conditions

Requesting predicted
probabilities

```
allmean  
      x1      x2      x3 pred.prob  
1 0.6480006 0.1338694 0.761851 0.8328555
```

When all predictor values are hold to their means, the probability of $y = 1$ is 83%.

Logit model: predicted probabilities with categorical variable

```
logit <- glm(y_bin ~ x1+x2+x3+opinion, family=binomial(link="logit"), data=mydata)
```

To estimate the predicted probabilities, we need to set the initial conditions. Getting predicted probabilities holding all predictors or independent variables to their means for each category of categorical variable 'opinion':

```
allmean <- data.frame(x1=rep(mean(mydata$x1),4),
                      x2=rep(mean(mydata$x2),4),
                      x3=rep(mean(mydata$x3),4),
                      opinion=as.factor(c("Str agree","Agree","Disag","Str disag")))
```

```
allmean
```

```
  x1      x2      x3 opinion
1 0.6480006 0.1338694 0.761851 Str agree
2 0.6480006 0.1338694 0.761851   Agree
3 0.6480006 0.1338694 0.761851   Disag
4 0.6480006 0.1338694 0.761851 Str disag
```

```
allmean <- cbind(allmean,predict(logit, newdata=allmean, type="response", se.fit=TRUE))
```

Creating a new dataset with the mean values of the predictors for each category



```
allmean
      x1      x2      x3 opinion      fit      se.fit residual.scale
1 0.6480006 0.1338694 0.761851 Str agree 0.8764826 0.07394431          1
2 0.6480006 0.1338694 0.761851   Agree 0.5107928 0.15099064          1
3 0.6480006 0.1338694 0.761851   Disag 0.9077609 0.06734568          1
4 0.6480006 0.1338694 0.761851 Str disag 0.9339310 0.06446677          1
```

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Logit model: predicted probabilities with categorical variable

```
# Renaming "fit" and "se.fit" columns
names(allmean)[names(allmean)=="fit"] = "prob"
```

```
names(allmean)[names(allmean)=="se.fit"] = "se.prob"
```

```
# Estimating confidence intervals
```

```
allmean$l1 = allmean$prob - 1.96*allmean$se.prob
```

```
allmean$u1 = allmean$prob + 1.96*allmean$se.prob
```

```
allmean
```

	x1	x2	x3	opinion	prob	se.prob	residual.scale	l1	u1
1	0.6480006	0.1338694	0.761851	Str agree	0.8764826	0.07394431	1	0.7315518	1.0214134
2	0.6480006	0.1338694	0.761851	Agree	0.5107928	0.15099064	1	0.2148511	0.8067344
3	0.6480006	0.1338694	0.761851	Disag	0.9077609	0.06734568	1	0.7757634	1.0397585
4	0.6480006	0.1338694	0.761851	Str disag	0.9339310	0.06446677	1	0.8075762	1.0602859

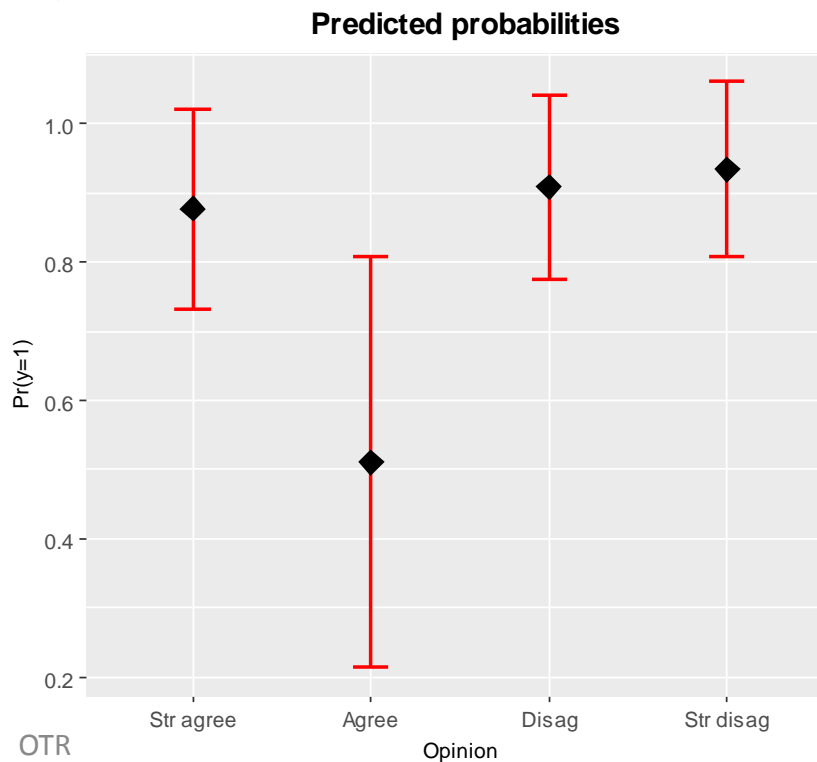
(continue next page)

Logit model: predicted probabilities with categorical variable

```
# Plotting predicted probabilities and confidence intervals using ggplot2
```

```
library(ggplot2)
```

```
ggplot(allmean, aes(x=opinion, y = prob)) +  
  geom_errorbar(aes(ymin = ll, ymax = ul), width = 0.2, lty=1, lwd=1, col="red") +  
  geom_point(shape=18, size=5, fill="black") +  
  scale_x_discrete(limits = c("Str agree", "Agree", "Disag", "Str disag")) +  
  labs(title= " Predicted probabilities", x="Opinion", y="Pr(y=1)", caption = "add footnote here") +  
  theme(plot.title = element_text(family = "sans", face="bold", size=13, hjust=0.5),  
        axis.title = element_text(family = "sans", size=9),  
        plot.caption = element_text(family = "sans", size=5))
```



Logit model: marginal effects

```
# Using package -mfx-
# See http://cran.r-project.org/web/packages/mfx/mfx.pdf
install.packages("mfx") #Do this only once
library(mfx)
logitmfx(y_bin ~ x1+x2+x3, data=mydata)
Call:
logitmfx(formula = y_bin ~ x1 + x2 + x3, data = mydata)

Marginal Effects:
      dF/dx Std. Err.      z    P>|z|
x1 0.119965  0.104836  1.1443 0.25249
x2 0.051024  0.041155  1.2398 0.21504
x3 0.104574  0.053890  1.9405 0.05232 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Marginal effects show the change in probability when the predictor or independent variable increases by one unit. For continuous variables this represents the instantaneous change given that the 'unit' may be very small. For binary variables, the change is from 0 to 1, so one 'unit' as it is usually thought.

Ordinal logit model

Getting sample data

```
library(foreign)
mydata <- read.dta("https://dss.princeton.edu/training/Panel101.dta")
```

Loading library -MASS-

```
library(MASS)
```

Running the ordered logit model

```
m1 <- polr(opinion ~ x1 + x2 + x3, data=mydata, Hess=TRUE)
```



```
summary(m1)
```

Call:

```
polr(formula = opinion ~ x1 + x2 + x3, data = mydata, Hess = TRUE)
```

Coefficients:

	Value	Std. Error	t value
x1	0.98140	0.5641	1.7397
x2	0.24936	0.2086	1.1954
x3	0.09089	0.1549	0.5867

Intercepts:

	Value	Std. Error	t value
Str agree Agree	-0.2054	0.4682	-0.4388
Agree Disag	0.7370	0.4697	1.5690
Disag Str disag	1.9951	0.5204	3.8335

Residual Deviance: 189.6382

AIC: 201.6382

Ordinal logit model: p-values

```
# Getting coefficients and p-values
```

```
m1.coef <- data.frame(coef(summary(m1)))
```

```
m1.coef$pval = round((pnorm(abs(m1.coef$t.value), lower.tail = FALSE) * 2), 2)
```

```
m1.coef
```

	Value	Std..Error	t.value	pval
x1	0.98139603	0.5641136	1.7397134	0.08
x2	0.24935530	0.2086027	1.1953599	0.23
x3	0.09089175	0.1549254	0.5866807	0.56
Str agree Agree	-0.20542664	0.4682027	-0.4387558	0.66
Agree Disag	0.73696754	0.4696907	1.5690486	0.12
Disag Str disag	1.99507902	0.5204282	3.8335334	0.00

Ordered logit model

The `stargazer()` function from the package `-stargazer` allows a publication quality of the logit model.

The model will be saved in the working directory under the name `'m1.htm'` which you can open with Word or any other word processor.

```
library(stargazer)
stargazer(m1, type="html", out="m1.htm")
```

<i>Dependent variable:</i>	
	opinion
x1	0.981* (0.564)
x2	0.249 (0.209)
x3	0.091 (0.155)
Observations	70
Note:	*p**p***p<0.01

NOTE: Use the option `type = "text"` if you want to see the results directly in the RStudio console.

Ordered logit model: odds ratios

Relative risk ratios allow an easier interpretation of the logit coefficients. They are the exponentiated value of the logit coefficients.

```
m1.or=exp(coef(m1))
```

```
m1.or
```

```
      x1      x2      x3  
2.668179 1.283198 1.095150
```

```
library(stargazer)
```

```
stargazer(m1, type="html", coef=list(m1.or), p.auto=FALSE, out="m1or.htm")
```

<i>Dependent variable:</i>	
	<i>opinion</i>
x1	2.668* (0.564)
x2	1.283 (0.209)
x3	1.095 (0.155)
Observations	70
Note:	*p**p***p<0.01

Keeping all other variables constant, when x1 increases one unit, it is 2.668 times more likely to be in a higher category. In other words, the odds of moving to a higher category in the outcome variable is 166% when x1 move one unit (2.66 – 1). The coefficient is significant.

NOTE: Use the option `type = "text"` if you want to see the results directly in the RStudio console.

Ordinal logit model: predicted probabilities

```
# Use "probs" for predicted probabilities
```

```
m1.pred <- predict(m1, type="probs")  
summary(m1.pred)
```

Str agree	Agree	Disag	Str disag
Min. :0.1040	Min. :0.1255	Min. :0.1458	Min. :0.07418
1st Qu.:0.2307	1st Qu.:0.2038	1st Qu.:0.2511	1st Qu.:0.17350
Median :0.2628	Median :0.2144	Median :0.2851	Median :0.23705
Mean :0.2869	Mean :0.2124	Mean :0.2715	Mean :0.22923
3rd Qu.:0.3458	3rd Qu.:0.2271	3rd Qu.:0.2949	3rd Qu.:0.26968
Max. :0.5802	Max. :0.2313	Max. :0.3045	Max. :0.48832

The bold numbers are the predicted probabilities of each category when all predictors are at their mean value

Ordinal logit model: predicted probabilities

```
# At specific values, example x1 and x2 at their means, and x3 = 1 and x3 = 2.
```

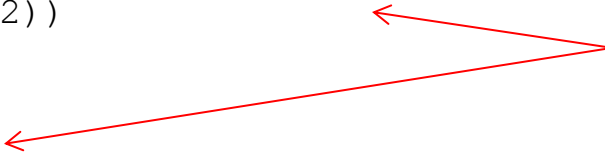
```
# Use "probs" for predicted probabilities given specific predictors
```

```
setup1 <- data.frame(x1=rep(mean(mydata$x1),2),  
                     x2=rep(mean(mydata$x2),2),  
                     x3=c(1,2))
```

```
setup1
```

	x1	x2	x3
1	0.6480006	0.1338694	1
2	0.6480006	0.1338694	2

Setup for new predicted probabilities



```
setup1[, c("pred.prob")] <- predict(m1, newdata=setup1, type="probs")
```

```
setup1
```

	x1	x2	x3	pred.prob.Str agree	pred.prob.Agree	pred.prob.Disag	pred.prob.Str disag
1	0.6480006	0.1338694	1	0.2757495	0.2184382	0.2804806	0.2253318
2	0.6480006	0.1338694	2	0.2579719	0.2135235	0.2869123	0.2415923

```
# Use "class" for the predicted category
```

```
setup1[, c("pred.prob")] <- predict(m1, newdata=setup1, type="class")
```

```
setup1
```

	x1	x2	x3	pred.prob
1	0.6480006	0.1338694	1	Disag
2	0.6480006	0.1338694	2	Disag

} These are the predicted categories given the new data

Ordinal logit model: marginal effects

```
# Load package "erer", use function ocMe() for marginal effects
```

```
library(erer)
```

```
x <- ocME(m1, x.mean=TRUE)
```

```
x
```

	effect.Str agree	effect.Agree	effect.Disag	effect.Str disag
x1	-0.198	-0.047	0.076	0.169
x2	-0.050	-0.012	0.019	0.043
x3	-0.018	-0.004	0.007	0.016

```
# Type the following if you want t and p-values
```

```
x$out
```

Multinomial logit model

```
# Loading the required packages
```

```
library(foreign)
library(nnet)
library(stargazer)
```

```
# Getting the sample data from UCLA
```

```
mydata = read.dta("http://www.ats.ucla.edu/stat/data/hsb2.dta")
```

```
# Checking the output (dependent) variable
```

```
table(mydata$ses)
```

low	middle	high
47	95	58

```
# By default the first category is the reference.
```

```
# To change it so 'middle' is the reference type
```

```
mydata$ses2 = relevel(mydata$ses, ref = "middle")
```

NOTE: This section is based on the UCLA website <http://www.ats.ucla.edu/stat/r/dae/mlogit.htm>, applied to data from the page http://www.ats.ucla.edu/stat/stata/output/stata_mlogit_output.htm. Results here reproduce the output in the latter to compare, and to provide an additional source to interpret outcomes.

Multinomial logit model

Running the multinomial logit model using the multinom() function

```
multil = multinom(ses2 ~ science + socst + female, data=mydata)
```



```
summary(multil)
```

Call:

```
multinom(formula = ses2 ~ science + socst + female, data = mydata)
```

Coefficients:

	(Intercept)	science	socst	femalefemale
low	1.912288	-0.02356494	-0.03892428	0.81659717
high	-4.057284	0.02292179	0.04300323	-0.03287211

Std. Errors:

	(Intercept)	science	socst	femalefemale
low	1.127255	0.02097468	0.01951649	0.3909804
high	1.222937	0.02087182	0.01988933	0.3500151

Residual Deviance: 388.0697

AIC: 404.0697

These are the logit coefficients relative to the reference category. For example, under 'science', the -0.02 suggests that for one unit increase in 'science' score, the logit coefficient for 'low' relative to 'middle' will go down by that amount, -0.02.

In other words, if your science score increases one unit, your chances of staying in the middle ses category are higher compared to staying in low ses.

Multinomial logit model

The multinom() function does not provide p-values, you can get significance of the coefficients using the stargazer() function from the package -stargazer.

The model will be saved in the working directory under the name 'multil.htm' which you can open with Word or any other word processor.

```
library(stargazer)
stargazer(multil, type="html", out="multil.htm")
```

	<i>Dependent variable:</i>	
	low	high
	(1)	(2)
science	-0.024 (0.021)	0.023 (0.021)
socst	-0.039** (0.020)	0.043** (0.020)
femalefemale	0.817** (0.391)	-0.033 (0.350)
Constant	1.912* (1.127)	-4.057*** (1.223)
Akaike Inf. Crit.	404.070	404.070
Note:	*p**p***p<0.01	

NOTE: Use the option `type = "text"` if you want to see the results directly in the RStudio console.

Multinomial logit model: relative risk ratios

Relative risk ratios allow an easier interpretation of the logit coefficients. They are the exponentiated value of the logit coefficients.

```
multil.rrr = exp(coef(multil))
```

```
multil.rrr
```

```
      (Intercept)    science    socst femalefemale
low    6.76855944  0.9767105  0.9618235    2.2627869
high   0.01729593  1.0231865  1.0439413    0.9676623
```

```
library(stargazer)
```

```
stargazer(multil, type="html", coef=list(multil.rrr), p.auto=FALSE, out="multilrrr.htm")
```

	<i>Dependent variable:</i>	
	low (1)	high (2)
science	0.977 (0.021)	1.023 (0.021)
socst	0.962** (0.020)	1.044** (0.020)
femalefemale	2.263** (0.391)	0.968 (0.350)
Constant	6.769* (1.127)	0.017*** (1.223)
Akaike Inf. Crit.	404.070	404.070
Note:	*p**p***p<0.01	

Keeping all other variables constant, if your science score increases one unit, you are 0.97 times more likely to stay in the low ses category as compared to the middle ses category (the risk or odds is 3% lower). The coefficient, however, is not significant.

Keeping all other variables constant, if your science score increases one unit, you are 1.02 times more likely to stay in the high ses category as compared to the middle ses category (the risk or odds is 2% higher). The coefficient, however, is not significant.

NOTE: Use the option `type = "text"` if you want to see the results directly in the RStudio console.

Ordinal logit model: predicted probabilities

```
# At specific values, example science and socst at their means for males and females.
```

```
# Use "probs" for predicted probabilities given specific predictors
```

```
allmean <- data.frame(science=rep(mean(mydata$science),2),  
                      socst=rep(mean(mydata$socst),2),  
                      female = c("male","female"))
```

```
allmean
```

```
  science  socst female  
1   51.85 52.405   male  
2   51.85 52.405  female
```

Setup for new predicted probabilities



```
allmean[, c("pred.prob")] <- predict(multil, newdata=allmean, type="probs")
```

```
allmean
```

```
  science  socst female pred.prob.middle pred.prob.low pred.prob.high  
1   51.85 52.405   male          0.5555769          0.1441171          0.3003061  
2   51.85 52.405  female          0.4739293          0.2781816          0.2478890
```

```
# Use "class" for the predicted category
```

```
allmean[, c("pred.prob")] <- predict(multil, newdata=allmean, type="class")
```

```
allmean
```

```
  science  socst female pred.prob  
1   51.85 52.405   male   middle  
2   51.85 52.405  female   middle
```

} These are the predicted categories given the new data

OTR

Sources

Greene, *Econometric Analysis*, 7th. ed.

Gelman and Hill, *Data Analysis Using Regression and Multilevel/Hierarchical Models*, 2007

UCLA, <http://www.ats.ucla.edu/stat/r/dae/>

StatsExchange, <http://stats.stackexchange.com/>

R packages:

-mfx- <http://cran.r-project.org/web/packages/mfx/mfx.pdf>

-erer- <http://cran.r-project.org/web/packages/erer/erer.pdf>