<u>Assignment 9: MN Logit & Ordered Logit Models</u>

1. Estimate the model using multinomial logit of yi. Perform IIA test. Interpret your estimated result (overall test, individual test, pseudo R 2, counted R 2)

Estimate model using multinomial logit of yi

```
. mlogit y x1 x2 x3 x4, nolog

Multinomial logistic regression                  Number of obs     =        152
                                                 LR chi2(20)       =      50.72
                                                 Prob > chi2       =     0.0002
Log likelihood = -203.28337                      Pseudo R2         =     0.1109

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
0            |
          x1 |  -1.832363   .8632903    -2.12   0.034    -3.524381   -.1403452
          x2 |   2.368735   1.168139     2.03   0.043      .079224    4.658246
          x3 |  -.0976971   .8455682    -0.12   0.908     -1.75498    1.559586
          x4 |  -.4905651   .3468626    -1.41   0.157    -1.170403     .189273
       _cons |   4.204706   4.763082     0.88   0.377    -5.130762    13.54017
-------------+----------------------------------------------------------------
1            |
          x1 |  -1.954381    .814615    -2.40   0.016    -3.550997   -.3577647
          x2 |   .3523473    .782471     0.45   0.652    -1.181268    1.885962
          x3 |   1.155726   1.030763     1.12   0.262     -.864533    3.175985
          x4 |   .8167134   .4673336     1.75   0.081    -.0992436    1.732671
       _cons |  -13.86033   7.056818    -1.96   0.050    -27.69144   -.0292169
-------------+----------------------------------------------------------------
2            |
          x1 |  -.8623688   .6749745    -1.28   0.201    -2.185294    .4605568
          x2 |   .7376981   .6909685     1.07   0.286    -.6165753    2.091972
          x3 |  -1.132118   .6624929    -1.71   0.087     -2.43058    .1663445
          x4 |  -.2862948   .2878698    -0.99   0.320    -.8505092    .2779195
       _cons |   3.302474   4.043716     0.82   0.414    -4.623064    11.22801
-------------+----------------------------------------------------------------
3            |
          x1 |  -2.236402   .6199683    -3.61   0.000    -3.451518   -1.021287
          x2 |   1.415342   .6376614     2.22   0.026     .1655491    2.665136
```

```
          x3 |  -.2635344   .6026228    -0.44   0.662    -1.444653    .9175846
          x4 |  -.2730998   .2507716    -1.09   0.276    -.7646032    .2184035
       _cons |   3.142763   3.534705     0.89   0.374    -3.785131    10.07066
-------------+----------------------------------------------------------------
4            |
          x1 |  -.1544581   .5644404    -0.27   0.784    -1.260741    .9518248
          x2 |   .2643829   .5265539     0.50   0.616    -.7676439     1.29641
          x3 |  -1.307232   .5372575    -2.43   0.015    -2.360237   -.2542264
          x4 |  -.3073979   .2338932    -1.31   0.189    -.7658201    .1510242
       _cons |   4.187597   3.285728     1.27   0.202    -2.252312    10.62751
-------------+----------------------------------------------------------------
5            |  (base outcome)
------------------------------------------------------------------------------
. est store m1
```

Perform IIA test

```
. qui mlogit y x1 x2 x3 x4, nolog
. est store mn
. qui mlogit y x1 x2 x3 x4 if y!=0, nolog
. est store m0
. qui mlogit y x1 x2 x3 x4 if y!=1, nolog
. est store m1
. qui mlogit y x1 x2 x3 x4 if y!=2, nolog
. est store m2
. qui mlogit y x1 x2 x3 x4 if y!=3, nolog
. est store m3
. qui mlogit y x1 x2 x3 x4 if y!=4, nolog
. est store m4
. qui mlogit y x1 x2 x3 x4 if y!=5, nolog
. est store m5
. hausman m0 mn, alleqs constant

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       m0           mn         Difference          S.E.
-------------+----------------------------------------------------------------
1            |
          x1 |   -2.076704    -1.954381       -.1223229        .2182392
          x2 |    .4188874     .3523473        .0665401        .0812799
```

```
          x3 |    1.259128     1.155726        .1034014        .2559311
          x4 |     .844917     .8167134        .0282036        .0188414
       _cons |   -14.32296    -13.86033       -.4626302        .4757965
-------------+----------------------------------------------------------------
2            |
          x1 |   -.8776991    -.8623688       -.0153303        .1003894
          x2 |    .7784094     .7376981        .0407113        .0974274
          x3 |   -1.102675    -1.132118        .0294425        .0601404
          x4 |   -.2891544    -.2862948       -.0028596         .074201
       _cons |    3.305654     3.302474        .0031795        .9924862
-------------+----------------------------------------------------------------
3            |
          x1 |   -2.293853    -2.236402        -.057451        .1278208
          x2 |    1.517187     1.415342         .101845        .1314902
          x3 |   -.1958864    -.2635344        .0676479        .1211386
          x4 |   -.2855371    -.2730998       -.0124372        .0799644
       _cons |     3.22992     3.142763        .0871563        1.069848
-------------+----------------------------------------------------------------
4            |
          x1 |   -.1519442    -.1544581        .0025139        .0765041
          x2 |    .2798297     .2643829        .0154468        .0538821
          x3 |   -1.288713    -1.307232        .0185189        .0180584
          x4 |   -.3050202    -.3073979        .0023777        .0479771
       _cons |    4.129014     4.187597       -.0585834         .638618
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from mlogit
           B = inconsistent under Ha, efficient under Ho; obtained from mlogit

    Test:  Ho:  difference in coefficients not systematic

                  chi2(20) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                           =        1.12
                 Prob>chi2 =      1.0000
                 (V_b-V_B is not positive definite)

. hausman mn m1, alleqs constant

                  ---- Coefficients ----
```

```
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       mn           m1         Difference          S.E.
-------------+----------------------------------------------------------------
0            |
          x1 |   -1.832363    -1.787321       -.0450417        .1269999
          x2 |    2.368735     2.317706        .0510288        .0760812
          x3 |   -.0976971    -.1965112        .0988141        .1130219
          x4 |   -.4905651    -.4902412        -.000324        .0349907
       _cons |    4.204706     4.281237       -.0765307        .5495838
-------------+----------------------------------------------------------------
2            |
          x1 |   -.8623688    -.8610516       -.0013172        .0701308
          x2 |    .7376981     .7438756       -.0061775        .0674606
          x3 |   -1.132118    -1.164413        .0322957        .0706786
          x4 |   -.2862948    -.2863155        .0000207        .0329969
       _cons |    3.302474     3.318143       -.0156684          .35511
-------------+----------------------------------------------------------------
3            |
          x1 |   -2.236402    -2.195589        -.040813        .0910901
          x2 |    1.415342     1.374017        .0413253        .0354064
          x3 |   -.2635344    -.3539281        .0903938        .0713504
          x4 |   -.2730998    -.2756534        .0025536        .0318896
       _cons |    3.142763     3.247364       -.1046002        .4284362
-------------+----------------------------------------------------------------
4            |
          x1 |   -.1544581    -.1580192        .0035611        .0366466
          x2 |    .2643829     .2761111       -.0117282        .0554939
          x3 |   -1.307232    -1.318868        .0116364        .0432539
          x4 |   -.3073979    -.3104499         .003052        .0238562
       _cons |    4.187597      4.23467       -.0470733         .230533
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from mlogit
           B = inconsistent under Ha, efficient under Ho; obtained from mlogit

    Test:  Ho:  difference in coefficients not systematic

                 chi2(20) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        1.22
```

```
                Prob>chi2 =      1.0000
                (V_b-V_B is not positive definite)


. hausman m2 mn, alleqs constant


Note: the rank of the differenced variance matrix (19) does not equal the number of
coefficients
        being tested (20); be sure this is what you expect, or there may be
problems computing the
        test.  Examine the output of your estimators for anything unexpected and
possibly consider
        scaling your variables so that the coefficients are on a similar scale.


                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       m2           mn         Difference          S.E.
-------------+----------------------------------------------------------------
0            |
          x1 |   -1.840991    -1.832363       -.0086281        .1414783
          x2 |    2.324036     2.368735       -.0446987               .
          x3 |   -.1324245    -.0976971       -.0347274        .0962939
          x4 |   -.4649274    -.4905651        .0256377        .0708576
       _cons |    3.915288     4.204706       -.2894183        1.187887
-------------+----------------------------------------------------------------
1            |
          x1 |   -2.103779    -1.954381       -.1493987        .2392173
          x2 |    .3568094     .3523473        .0044621        .0910257
          x3 |    1.289565     1.155726        .1338392        .2753211
          x4 |    .8876743     .8167134        .0709609        .1133227
       _cons |   -14.92105    -13.86033       -1.060724        1.696957
-------------+----------------------------------------------------------------
3            |
          x1 |   -2.260884    -2.236402        -.024482        .1130104
          x2 |    1.435022     1.415342        .0196793         .008073
          x3 |   -.2622615    -.2635344        .0012728        .1016883
          x4 |   -.2558297    -.2730998        .0172702        .0732383
       _cons |    2.897425     3.142763       -.2453387        1.078419
-------------+----------------------------------------------------------------
4            |
          x1 |   -.1360249    -.1544581        .0184332        .1024918
```

```
          x2 |    .2997382     .2643829        .0353553        .0875063
          x3 |   -1.296671    -1.307232        .0105607         .050314
          x4 |   -.3130267    -.3073979       -.0056287        .0528189
       _cons |    4.225917     4.187597        .0383196        .7006239
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from mlogit
           B = inconsistent under Ha, efficient under Ho; obtained from mlogit

    Test:  Ho:  difference in coefficients not systematic

                 chi2(19) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        0.60
                Prob>chi2 =      1.0000
                (V_b-V_B is not positive definite)

. hausman m3 mn, alleqs constant

Note: the rank of the differenced variance matrix (19) does not equal the number of
coefficients
        being tested (20); be sure this is what you expect, or there may be
problems computing the
        test.  Examine the output of your estimators for anything unexpected and
possibly consider
        scaling your variables so that the coefficients are on a similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       m3           mn         Difference          S.E.
-------------+----------------------------------------------------------------
0            |
          x1 |    -1.81674    -1.832363        .0156229         .090417
          x2 |    2.242124     2.368735       -.1266108               .
          x3 |   -.0269395    -.0976971        .0707576        .1412581
          x4 |   -.4149522    -.4905651         .075613               .
       _cons |     3.16993     4.204706       -1.034776               .
-------------+----------------------------------------------------------------
1            |
          x1 |   -1.851336    -1.954381        .1030449               .
          x2 |    .2971948     .3523473       -.0551525               .
          x3 |    .9814713     1.155726       -.1742549               .
```

```
          x4 |    .7589511     .8167134       -.0577624               .
       _cons |   -12.89888    -13.86033        .9614453               .
-------------+----------------------------------------------------------------
2            |
          x1 |   -.8174041    -.8623688        .0449647        .1070329
          x2 |    .7014645     .7376981       -.0362336               .
          x3 |    -1.10005    -1.132118        .0320678        .0760416
          x4 |    -.244059    -.2862948        .0422358               .
       _cons |    2.672306     3.302474       -.6301678               .
-------------+----------------------------------------------------------------
4            |
          x1 |   -.1047128    -.1544581        .0497453        .1007949
          x2 |    .2577302     .2643829       -.0066527               .
          x3 |   -1.295478    -1.307232        .0117541        .0648551
          x4 |   -.2751781    -.3073979        .0322199               .
       _cons |    3.687136     4.187597       -.5004613               .
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from mlogit
           B = inconsistent under Ha, efficient under Ho; obtained from mlogit

    Test:  Ho:  difference in coefficients not systematic

                 chi2(19) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        1.95
                Prob>chi2 =      1.0000
                (V_b-V_B is not positive definite)

. hausman m4 mn, alleqs constant

Note: the rank of the differenced variance matrix (19) does not equal the number of coefficients
        being tested (20); be sure this is what you expect, or there may be problems computing the
        test.  Examine the output of your estimators for anything unexpected and possibly consider
        scaling your variables so that the coefficients are on a similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       m4           mn         Difference          S.E.
```

```
-------------+----------------------------------------------------------------
0            |
          x1 |   -1.917478    -1.832363       -.0851147        .0639035
          x2 |    2.399049     2.368735        .0303146        .1991226
          x3 |   -.0750429    -.0976971        .0226542        .1709826
          x4 |   -.4760917    -.4905651        .0144735               .
       _cons |    4.002073     4.204706       -.2026339               .
-------------+----------------------------------------------------------------
1            |
          x1 |   -1.887951    -1.954381        .0664294               .
          x2 |    .4256484     .3523473        .0733011               .
          x3 |     1.13251     1.155726       -.0232167        .1476198
          x4 |    .7670503     .8167134       -.0496631               .
       _cons |   -13.20158    -13.86033        .6587452               .
-------------+----------------------------------------------------------------
2            |
          x1 |    -.902955    -.8623688       -.0405861               .
          x2 |     .746173     .7376981        .0084748        .0388948
          x3 |   -1.134476    -1.132118       -.0023583               .
          x4 |   -.2704256    -.2862948        .0158692               .
       _cons |    3.098155     3.302474       -.2043196               .
-------------+----------------------------------------------------------------
3            |
          x1 |   -2.273025    -2.236402        -.036623        .0583652
          x2 |    1.445561     1.415342         .030219        .1510594
          x3 |   -.2614692    -.2635344        .0020652        .1388544
          x4 |    -.277248    -.2730998       -.0041482               .
       _cons |     3.19799     3.142763        .0552263               .
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from mlogit
           B = inconsistent under Ha, efficient under Ho; obtained from mlogit

    Test:  Ho:  difference in coefficients not systematic

                 chi2(19) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        1.74
                Prob>chi2 =      1.0000
                (V_b-V_B is not positive definite)
```

```
. hausman m5 mn, alleqs constant

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       m5           mn         Difference          S.E.
-------------+----------------------------------------------------------------
0            |
          x1 |   -1.478476    -1.832363        .3538867         .323685
          x2 |    2.278957     2.368735       -.0897779        .4784974
          x3 |     1.24603    -.0976971        1.343728        .3205611
          x4 |   -.2456624    -.4905651        .2449027        .1649645
       _cons |    .6496392     4.204706       -3.555067        2.072463
-------------+----------------------------------------------------------------
1            |
          x1 |   -1.627068    -1.954381        .3273123          .40496
          x2 |    -.069953     .3523473       -.4223003        .5656839
          x3 |     2.46098     1.155726        1.305253        .3338389
          x4 |    1.195286     .8167134        .3785723        .2656054
       _cons |   -19.05759    -13.86033       -5.197267        3.656087
-------------+----------------------------------------------------------------
2            |
          x1 |   -.6682758    -.8623688        .1940931        .2651033
          x2 |     .474385     .7376981       -.2633131        .4081365
          x3 |    .1898543    -1.132118        1.321972        .3376765
          x4 |     .008459    -.2862948        .2947538        .1387016
       _cons |   -.7364481     3.302474       -4.038922        1.875707
-------------+----------------------------------------------------------------
3            |
          x1 |   -1.926976    -2.236402        .3094262        .3279383
          x2 |    1.211761     1.415342        -.203581        .4261408
          x3 |    1.015451    -.2635344        1.278986        .3424029
          x4 |   -.0014303    -.2730998        .2716696        .1506073
       _cons |   -.6350097     3.142763       -3.777773        2.002128
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from mlogit
           B = inconsistent under Ha, efficient under Ho; obtained from mlogit
```

```
    Test:  Ho:  difference in coefficients not systematic

                 chi2(20) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       38.42
                Prob>chi2 =      0.0079
                (V_b-V_B is not positive definite)
```

We cannot reject the null hypothesis that IIA is valid when dropping y=0,1,…4. However, we can reject the null when dropping y=5. Thus, IIA is invalid.

Interpret your estimated result (overall test, individual test, pseudo R2, counted R2)

We can reject the null in the overall LR-Chi-square-test (0.0002<0.05); thus all coefficients are overall significant. Moreover, looking at the individual z-test, I have marked the insignificant coefficients with the red color.

The pseudo R2 is 0.111. This R2 can only be used for comparison not interpretation. Moreover, the overall counted R2 is 0.086, meaning that the model is correctly classified by 8.6%. This model might not be very good for prediction usage.

Pseudo R2 and Counted R2 results are as follows…

```
. fitstat

Measures of Fit for mlogit of y

Log-Lik Intercept Only:     -228.644     Log-Lik Full Model:         -203.283
D(122):                      406.567     LR(20):                       50.721
                                         Prob > LR:                     0.000
McFadden's R2:                 0.111     McFadden's Adj R2:            -0.020
Maximum Likelihood R2:         0.284     Cragg & Uhler's R2:            0.298
Count R2:                      0.086     Adj Count R2:                  0.021
AIC:                           3.070     AIC*n:                       466.567
BIC:                        -206.347     BIC':                         49.757
```

2. Estimate the model using order logit of yi. Interpret your estimated result (overall test, individual test, pseudo R2, counted R2)

```
. ologit y x1 x2 x3 x4, nolog

Ordered logistic regression                      Number of obs     =        152
                                                 LR chi2(4)        =      24.81
                                                 Prob > chi2       =     0.0001
Log likelihood = -216.23748                      Pseudo R2         =     0.0543
```

```
------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |    1.26067   .3475145     3.63   0.000     .5795538    1.941786
          x2 |  -.8530234   .3508641    -2.43   0.015    -1.540705   -.1653424
          x3 |   .2068371   .3398536     0.61   0.543    -.4592637    .8729379
          x4 |   .1261028   .1511501     0.83   0.404    -.1701459    .4223515
-------------+----------------------------------------------------------------
       /cut1 |  -.8807685   2.139511                     -5.074134    3.312597
       /cut2 |  -.0328063   2.126237                     -4.200155    4.134542
       /cut3 |   .6557008   2.118367                     -3.496223    4.807624
       /cut4 |    1.48964   2.117389                     -2.660365    5.639646
       /cut5 |   2.283969   2.124223                     -1.879432    6.447371
------------------------------------------------------------------------------
```

```
. fitstat
Measures of Fit for ologit of y

Log-Lik Intercept Only:       -228.644   Log-Lik Full Model:            -216.237
D(143):                        432.475   LR(4):                           24.812
                                         Prob > LR:                        0.000
McFadden's R2:                   0.054   McFadden's Adj R2:                0.015
ML (Cox-Snell) R2:               0.151   Cragg-Uhler(Nagelkerke) R2:       0.158
McKelvey & Zavoina's R2:         0.157
Variance of y*:                  3.904   Variance of error:                3.290
Count R2:                        0.480   Adj Count R2:                     0.025
AIC:                             2.964   AIC*n:                          450.475
BIC:                          -285.940   BIC':                            -4.717
BIC used by Stata:             477.690   AIC used by Stata:              450.475
```

Interpret your estimated result (overall test, individual test, pseudo R2, counted R2)

We can reject the null in the overall LR-Chi-square-test (0.0001<0.05); thus, all coefficients are overall significant. Moreover, looking at the individual z-test, I have marked the insignificant coefficients with the red color.

The pseudo R2 is 0.054, which is more than that of the multinomial logit (0.111). Moreover, the overall counted R2 is 0.480, meaning that the model is 48% correctly classified, which is better than the previous one.

3. From (a) and (b), compare the two models. Perform order logit test. Which model is more appropriated in this case? Why?

<u>Perform the order logit test</u>

```
. g y_15=(y>0)

. g y_25=(y>1)

. g y_35=(y>2)

. g y_45=(y>3)

. g y_55=(y>4)

. qui logit y_15 x1 x2 x3 x4, nolog

. est store m15

. qui logit y_25 x1 x2 x3 x4, nolog

. est store m25

. qui logit y_35 x1 x2 x3 x4, nolog

. est store m35

. qui logit y_45 x1 x2 x3 x4, nolog

. est store m45

. qui logit y_55 x1 x2 x3 x4, nolog

. est store m55

. suest m15 m25 m35 m45 m55

Simultaneous results for m15, m25, m35, m45, m55

                                                Number of obs     =        152

------------------------------------------------------------------------------

             |               Robust

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

-------------+----------------------------------------------------------------

m15_y_15     |

          x1 |   1.097122   .9033857     1.21   0.225    -.6734812    2.867725

          x2 |   -1.82336   1.135405    -1.61   0.108    -4.048713    .4019928

          x3 |  -.3069072    .803698    -0.38   0.703    -1.882126    1.268312

          x4 |   .3527502   .3544918     1.00   0.320    -.3420409    1.047541

       _cons |  -1.099312   4.856106    -0.23   0.821     -10.6171    8.418481

-------------+----------------------------------------------------------------

m25_y_25     |

          x1 |   1.264527   .5825003     2.17   0.030     .1228478    2.406207

          x2 |  -.7792338    .604258    -1.29   0.197    -1.963558    .4050901

          x3 |  -.8053988   .6052151    -1.33   0.183    -1.991599     .380801

          x4 |  -.2074297   .3082284    -0.67   0.501    -.8115462    .3966868

       _cons |   5.389609   4.422033     1.22   0.223    -3.277416    14.05663
```

```
-------------+----------------------------------------------------------------
m35_y_35     |
          x1 |    .864886   .4721274     1.83   0.067    -.0604667    1.790239
          x2 |  -.6170464   .4658079    -1.32   0.185    -1.530013    .2959203
          x3 |  -.0281734   .4629933    -0.06   0.951    -.9356237    .8792769
          x4 |  -.0449685   .2176813    -0.21   0.836    -.4716161    .3816791
       _cons |   1.899683   3.086536     0.62   0.538    -4.149816    7.949182
-------------+----------------------------------------------------------------
m45_y_45     |
          x1 |   1.679889   .4359289     3.85   0.000     .8254838    2.534294
          x2 |  -1.051402   .4339843    -2.42   0.015    -1.901996   -.2008088
          x3 |  -.1154448   .4385046    -0.26   0.792     -.974898    .7440085
          x4 |   .0623465   .1817055     0.34   0.732    -.2937897    .4184826
       _cons |  -.4960081   2.567482    -0.19   0.847     -5.52818    4.536164
-------------+----------------------------------------------------------------
m55_y_55     |
          x1 |   1.213482   .3980963     3.05   0.002     .4332271    1.993736
          x2 |  -.8226954   .3994092    -2.06   0.039    -1.605523   -.0398677
          x3 |    .672316   .4147506     1.62   0.105    -.1405801    1.485212
          x4 |   .2113165   .1907187     1.11   0.268    -.1624853    .5851183
       _cons |  -3.847181   2.713683    -1.42   0.156    -9.165902    1.471539
------------------------------------------------------------------------------

. test [m15_y_15]x1=[m25_y_25]x1=[m35_y_35]x1=[m45_y_45]x1=[m55_y_55]x1

 ( 1)  [m15_y_15]x1 - [m25_y_25]x1 = 0
 ( 2)  [m15_y_15]x1 - [m35_y_35]x1 = 0
 ( 3)  [m15_y_15]x1 - [m45_y_45]x1 = 0
 ( 4)  [m15_y_15]x1 - [m55_y_55]x1 = 0

           chi2(  4) =    6.95
         Prob > chi2 =    0.1384

. test [m15_y_15]x2=[m25_y_25]x2=[m35_y_35]x2=[m45_y_45]x2=[m55_y_55]x2

 ( 1)  [m15_y_15]x2 - [m25_y_25]x2 = 0
 ( 2)  [m15_y_15]x2 - [m35_y_35]x2 = 0
 ( 3)  [m15_y_15]x2 - [m45_y_45]x2 = 0
```

```
 ( 4)  [m15_y_15]x2 - [m55_y_55]x2 = 0

           chi2(  4) =    3.24
         Prob > chi2 =    0.5186

. test [m15_y_15]x3=[m25_y_25]x3=[m35_y_35]x3=[m45_y_45]x3=[m55_y_55]x3

 ( 1)  [m15_y_15]x3 - [m25_y_25]x3 = 0
 ( 2)  [m15_y_15]x3 - [m35_y_35]x3 = 0
 ( 3)  [m15_y_15]x3 - [m45_y_45]x3 = 0
 ( 4)  [m15_y_15]x3 - [m55_y_55]x3 = 0

           chi2(  4) =    8.55
         Prob > chi2 =    0.0734

. test [m15_y_15]x4=[m25_y_25]x4=[m35_y_35]x4=[m45_y_45]x4=[m55_y_55]x4

 ( 1)  [m15_y_15]x4 - [m25_y_25]x4 = 0
 ( 2)  [m15_y_15]x4 - [m35_y_35]x4 = 0
 ( 3)  [m15_y_15]x4 - [m45_y_45]x4 = 0
 ( 4)  [m15_y_15]x4 - [m55_y_55]x4 = 0

           chi2(  4) =    7.47
         Prob > chi2 =    0.1130

. ologit y x1 x2 x3 x4, nolog
Ordered logistic regression                       Number of obs     =        152
                                                  LR chi2(4)        =      24.81
                                                  Prob > chi2       =     0.0001
Log likelihood = -216.23748                       Pseudo R2         =     0.0543

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |    1.26067   .3475145     3.63   0.000     .5795538    1.941786
          x2 |  -.8530234   .3508641    -2.43   0.015    -1.540705   -.1653424
          x3 |   .2068371   .3398536     0.61   0.543    -.4592637    .8729379
          x4 |   .1261028   .1511501     0.83   0.404    -.1701459    .4223515
```

```
-------------+----------------------------------------------------------------
       /cut1 |  -.8807685   2.139511                     -5.074134    3.312597
       /cut2 |  -.0328063   2.126237                     -4.200155    4.134542
       /cut3 |   .6557008   2.118367                     -3.496223    4.807624
       /cut4 |    1.48964   2.117389                     -2.660365    5.639646
       /cut5 |   2.283969   2.124223                     -1.879432    6.447371
------------------------------------------------------------------------------
```

From the ordered logit test, it could be interpreted that ordered logit should be used because we can accept all the null hypothesis.

When looking at the information criteria: AIC and BIC, the results obtained from the command fitstat above are…

Multinomial logit BIC = -206.347

Ordered logit BIC = -285.940

It can be concluded that ordered logit should be used because it poses a smaller BIC.

Which model is more appropriated in this case? Why?

According to the nature of the dependent variable along with the ordered logit test and information criteria, the model in (b): ordered logit is a more appropriated than that in(a): multinomial logit.

4. Compute marginal effect at mean and median of both models

At mean

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

```
Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==0), predict(outcome(0))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.0499158   .0547573    -0.91   0.362    -.1572382    .0574065
          x2 |   .1178047   .0700462     1.68   0.093    -.0194832    .2550927
          x3 |  -.0303886   .0667857    -0.46   0.649    -.1612862    .1005089
          x4 |  -.0880564   .0400957    -2.20   0.028    -.1666425   -.0094702
------------------------------------------------------------------------------
```

```
. margins, dydx(*) predict(outcome(1))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==1), predict(outcome(1))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.0256552    .056212    -0.46   0.648    -.1358287    .0845183
          x2 |  -.1146446   .0688186    -1.67   0.096    -.2495266    .0202374
          x3 |   .1187979   .0676823     1.76   0.079    -.0138571    .2514528
          x4 |   .1523467   .0500055     3.05   0.002     .0543377    .2503556
------------------------------------------------------------------------------

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

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==2), predict(outcome(2))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.0247692   .0487558    -0.51   0.611    -.1203289    .0707905
          x2 |  -.0135825   .0649086    -0.21   0.834     -.140801     .113636
          x3 |  -.0677042    .057129    -1.19   0.236     -.179675    .0442666
          x4 |   -.006787   .0274649    -0.25   0.805    -.0606173    .0470432
```

```
. margins, dydx(*) predict(outcome(3))

Average marginal effects                        Number of obs     =        152
```

```
Model VCE    : OIM

Expression   : Pr(y==3), predict(outcome(3))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.2589438   .0723984    -3.58   0.000    -.4008421   -.1170455
          x2 |   .2300615   .0804258     2.86   0.004     .0724297    .3876932
          x3 |   -.004475   .0565331    -0.08   0.937    -.1152779    .1063279
          x4 |   -.047432   .0317246    -1.50   0.135     -.109611    .0147471
-----------------------------------------------------------------------------
```

. margins, dydx(*) predict(outcome(4))

```
Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==4), predict(outcome(4))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |    .094683   .0653609     1.45   0.147    -.0334221     .222788
          x2 |  -.0043281   .0669036    -0.06   0.948    -.1354568    .1268006
          x3 |  -.1554691   .0694493    -2.24   0.025    -.2915872   -.0193511
          x4 |   -.051556   .0388786    -1.33   0.185    -.1277567    .0246446
------------------------------------------------------------------------------
```

. margins, dydx(*) predict(outcome(5))

```
Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==5), predict(outcome(5))
```

dy/dx w.r.t. : x1 x2 x3 x4

	dy/dx (Delta-method)	Std. Err.	z	P>|z|	[95% Conf.	Interval]
x1	.2646011	.0789902	3.35	0.001	.1097832	.4194189
x2	-.215311	.0772763	-2.79	0.005	-.3667699	-.0638521
x3	.1392391	.0831653	1.67	0.094	-.0237618	.3022401
x4	.0414847	.0387655	1.07	0.285	-.0344942	.1174636

At median

. margins, dydx(*) predict(outcome(0)) at((median))

Average marginal effects   Number of obs   =   152

Model VCE   : OIM

Expression   : Pr(y==0), predict(outcome(0))

dy/dx w.r.t. : x1 x2 x3 x4

	dy/dx (Delta-method)	Std. Err.	z	P>|z|	[95% Conf.	Interval]
x1	-.0499158	.0547573	-0.91	0.362	-.1572382	.0574065
x2	.1178047	.0700462	1.68	0.093	-.0194832	.2550927
x3	-.0303886	.0667857	-0.46	0.649	-.1612862	.1005089
x4	-.0880564	.0400957	-2.20	0.028	-.1666425	-.0094702

. margins, dydx(*) predict(outcome(1)) at((median))

```
Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==1), predict(outcome(1))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.0256552    .056212    -0.46   0.648    -.1358287    .0845183
          x2 |  -.1146446   .0688186    -1.67   0.096    -.2495266    .0202374
          x3 |   .1187979   .0676823     1.76   0.079    -.0138571    .2514528
          x4 |   .1523467   .0500055     3.05   0.002     .0543377    .2503556
------------------------------------------------------------------------------
```

. margins, dydx(*) predict(outcome(2)) at((median))

```
Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==2), predict(outcome(2))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.0247692   .0487558    -0.51   0.611    -.1203289    .0707905
          x2 |  -.0135825   .0649086    -0.21   0.834     -.140801     .113636
          x3 |  -.0677042    .057129    -1.19   0.236     -.179675    .0442666
          x4 |   -.006787   .0274649    -0.25   0.805    -.0606173    .0470432
------------------------------------------------------------------------------
```

. margins, dydx(*) predict(outcome(3)) at((median))

```
Average marginal effects                        Number of obs     =        152
Model VCE    : OIM
```

```
Expression   : Pr(y==3), predict(outcome(3))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.2589438   .0723984    -3.58   0.000    -.4008421   -.1170455
          x2 |   .2300615   .0804258     2.86   0.004     .0724297    .3876932
          x3 |   -.004475   .0565331    -0.08   0.937    -.1152779    .1063279
          x4 |   -.047432   .0317246    -1.50   0.135     -.109611    .0147471
------------------------------------------------------------------------------
```

. margins, dydx(*) predict(outcome(4)) at((median))

```
Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==4), predict(outcome(4))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |    .094683   .0653609     1.45   0.147    -.0334221     .222788
          x2 |  -.0043281   .0669036    -0.06   0.948    -.1354568    .1268006
          x3 |  -.1554691   .0694493    -2.24   0.025    -.2915872   -.0193511
          x4 |   -.051556   .0388786    -1.33   0.185    -.1277567    .0246446
------------------------------------------------------------------------------
```

. margins, dydx(*) predict(outcome(5)) at((median))

```
Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==5), predict(outcome(5))
dy/dx w.r.t. : x1 x2 x3 x4
```

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
x1	.2646011	.0789902	3.35	0.001	.1097832	.4194189
x2	-.215311	.0772763	-2.79	0.005	-.3667699	-.0638521
x3	.1392391	.0831653	1.67	0.094	-.0237618	.3022401
x4	.0414847	.0387655	1.07	0.285	-.0344942	.1174636

Average marginal effects Number of obs = 152

Model VCE : OIM

Expression : Pr(y==4), predict(outcome(4))

dy/dx w.r.t. : x1 x2 x3 x4

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
x1	.094683	.0653609	1.45	0.147	-.0334221	.222788
x2	-.0043281	.0669036	-0.06	0.948	-.1354568	.1268006
x3	-.1554691	.0694493	-2.24	0.025	-.2915872	-.0193511
x4	-.051556	.0388786	-1.33	0.185	-.1277567	.0246446