Assignment 4

From the data set `assign4.dta`:

The study on bankruptcy firm employs the following regression model.

$$z_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \beta_4 x_{4i} \tag{1}$$

The log-likelihood function of this model is as follows:

$$\ln L = \begin{cases} \ln \Phi(z_i) \ if \ \ y_i = 1 \\ \ln \Phi(-z_i) \ if \ \ y_i = 0 \end{cases} \tag{2}$$

where: y_i = 1 for bankruptcy firm and 0 otherwise.

x_{1i} = Debt coverage ratio of firm i

x_{2i} = Liquidity ratio of firm i

x_{3i} = Profitability index of firm i

x_{4i} = Solidity ratio of firm i

Let $\Phi(.)$ = Logistic probability distribution function. $\Phi(z_i) = \dfrac{1}{1+e^{-z_i}}$

From the given data set (`assig8-2.dta`):

a. Estimate the above models using MLE with Newton-Ralphson algorithm.

b. Perform hypothesis testing whether $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ using LR-test and Wald test.

c. Estimate the above models using MLE with BHHH algorithm, make comparison of the estimated result with the result from (1), and give explanation why are they different?

Let $\Phi(.)$ = Cumulation standard normal probability distribution function and

$$z_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} \tag{3}$$

d. Estimate the models using MLE with Newton-Ralphson algorithm.

Assume that there exists heteroskedasticity in the model as: $\sigma_i^2 = \exp(\gamma x_{4i})^2$, then,

$\Phi(.)$ = Cumulation standard normal probability distribution function $\Phi\ \ z_i / \exp(\gamma x_{4i})$

e. Estimate the models with heteroskedasticity using MLE with Newton-Ralphson algorithm. Perform LR-test whether there exists significant heteroskedasticity.

The study on bankruptcy firm employs the following regression model.

$$z_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \beta_4 x_{4i} \qquad (1)$$

The log-likelihood function of this model is as follows:

$$\ln L = \begin{cases} \ln \Phi(z_i) \ if \ \ y_i = 1 \\ \ln \Phi(-z_i) \ if \ \ y_i = 0 \end{cases} \qquad (2)$$

where: y_i = 1 for bankruptcy firm and 0 otherwise.
x_{1i} = Debt coverage ratio of firm i
x_{2i} = Liquidity ratio of firm i
x_{3i} = Profitability index of firm i
x_{4i} = Solidity ratio of firm i

Let $\Phi(.)$ = Logistic probability distribution function. $\Phi(z_i) = \dfrac{1}{1+e^{-z_i}}$

a. Estimate the above models using MLE with Newton-Ralphson algorithm.

$$\underset{(0.5531237)}{z_i = -1.400447} + \underset{(0.1686119)}{0.4835128\, X_{1i}} + \underset{(0.5001373)}{1.454009\, X_{2i}} + \underset{(0.7757021)}{2.173186\, X_{3i}} + \underset{(0.7138855)}{1.855464\, X_{4i}} \quad \text{—— } (1)$$

b. Perform hypothesis testing whether $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ using LR-test and Wald test.

Wald

$\chi^2_4 = 22.79$

Prob > χ^2 = 0.001

LR test

LR $\chi^2_4 = 63$

It reject the null the null hypothesis which implies that they are jointly significant

c. Estimate the above models using MLE with BHHH algorithm, make comparison of the estimated result with the result from (1), and give explanation why are they different?

under BHHH

$$\underset{(0.5625155)}{z_i = -1.400063} + \underset{(0.1542635)}{0.4833318\, X_{1i}} + \underset{(0.5979925)}{1.453275\, X_{2i}} + \underset{(0.8559781)}{2.172641\, X_{3i}} + \underset{(0.7142729)}{1.854961\, X_{4i}} \quad \text{—— } (2)$$

By (1) and (2), it shows that BHHH's each $\hat{\beta}$ is a bit smaller. The reason is that BHHH use only gradient function in the method while Newton - Raphson hessian and gradient function

d. Estimate the models using MLE with Newton-Ralphson algorithm.

$$\underset{(0.2765064)}{z_i = -0.7729211} + \underset{(0.0871351)}{0.359244\, X_{1i}} + \underset{(0.3924845)}{1.139607\, X_{2i}}$$

e. Estimate the models with heteroskedasticity using MLE with Newton-Ralphson algorithm. Perform LR-test whether there exists significant heteroskedasticity.

LR-test $\chi^2_4 = 21.14$ //

Pvalue = 0

```
  ___  ____  ____  ____  ____(R)
 /__    /   ____/   /   ____/
___/   /   /___/   /   /___/
  Statistics/Data Analysis
```

```
      name:  <unnamed>
       log:  C:\Users\Pongpanot\Downloads\fixed ASS4_MLE.smcl
  log type:  smcl
 opened on:  18 Feb 2021, 01:36:16

1 . do "C:\Users\PONGPA~1\AppData\Local\Temp\STD00000000.tmp"

2 . program ml_logit
    1.  args lnf theta
    2.  quietly replace `lnf'=ln(1/(1+exp(-`theta'))) if $ML_y1==1
    3.  quietly replace `lnf'=ln(1-(1/(1+exp(-`theta')))) if $ML_y1==0
    4. end

3 .
  end of do-file

4 . ml model lf ml_logit (y= x1 x2 x3 x4)

5 . ml max

  initial:       log likelihood = -90.109133
  alternative:   log likelihood = -86.130008
  rescale:       log likelihood = -86.130008
  Iteration 0:   log likelihood = -86.130008
  Iteration 1:   log likelihood = -66.355929
  Iteration 2:   log likelihood = -63.390472
  Iteration 3:   log likelihood = -57.767786
  Iteration 4:   log likelihood = -55.029892
  Iteration 5:   log likelihood = -54.628025
  Iteration 6:   log likelihood = -54.627603
  Iteration 7:   log likelihood = -54.627603

                                                Number of obs     =        130
                                                Wald chi2(4)      =      22.79
  Log likelihood = -54.627603                   Prob > chi2       =     0.0001
```

y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
x1	.4835128	.1686119	2.87	0.004	.1530396	.813986
x2	1.454009	.5001373	2.91	0.004	.4737578	2.43426
x3	2.173186	.7757021	2.80	0.005	.652838	3.693535
x4	1.855464	.7138855	2.60	0.009	.4562739	3.254653
_cons	-1.400447	.5531237	-2.53	0.011	-2.484549	-.316344

```
6 . test (x1=0) (x2=0) (x3=0) (x4=0)

   ( 1)  [eq1]x1 = 0
   ( 2)  [eq1]x2 = 0
   ( 3)  [eq1]x3 = 0
   ( 4)  [eq1]x4 = 0

           chi2(  4) =   22.79
         Prob > chi2 =    0.0001
```

```
 7 . est store ur

 8 . ml model lf ml_logit (y=)

 9 . ml max

   initial:       log likelihood = -90.109133
   alternative:   log likelihood = -86.130008
   rescale:       log likelihood = -86.130008
   Iteration 0:   log likelihood = -86.130008
   Iteration 1:   log likelihood = -86.129902
   Iteration 2:   log likelihood = -86.129902

                                                  Number of obs     =        130
                                                  Wald chi2(0)      =          .
   Log likelihood = -86.129902                    Prob > chi2       =          .

   ------------------------------------------------------------------------------
                y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
   ---------------+--------------------------------------------------------------
            _cons |   .5026289   .1809802     2.78   0.005     .1479141    .8573436
   ------------------------------------------------------------------------------

10 . est store res

11 . lrtest ur res

   Likelihood-ratio test                                 LR chi2(4)  =     63.00
   (Assumption: res nested in ur)                        Prob > chi2 =    0.0000

12 . ml model lf ml_logit (y= x1 x2 x3 x4), tech(bhhh)

13 . ml max

   initial:       log likelihood = -90.109133
   alternative:   log likelihood = -86.130008
   rescale:       log likelihood = -86.130008
   Iteration 0:   log likelihood = -86.130008
   Iteration 1:   log likelihood = -64.805009
   Iteration 2:   log likelihood = -58.076419
   Iteration 3:   log likelihood = -55.104476
   Iteration 4:   log likelihood = -54.737891
   Iteration 5:   log likelihood = -54.673222
   Iteration 6:   log likelihood = -54.653417
   Iteration 7:   log likelihood = -54.641919
   Iteration 8:   log likelihood = -54.636424
   Iteration 9:   log likelihood = -54.632812
   Iteration 10:  log likelihood = -54.630848
   Iteration 11:  log likelihood = -54.629561
   Iteration 12:  log likelihood = -54.628821
   Iteration 13:  log likelihood = -54.628345
   Iteration 14:  log likelihood = -54.628063
   Iteration 15:  log likelihood = -54.627885
   Iteration 16:  log likelihood = -54.627777
   Iteration 17:  log likelihood =  -54.62771
   Iteration 18:  log likelihood = -54.627669
   Iteration 19:  log likelihood = -54.627644
   Iteration 20:  log likelihood = -54.627628
   Iteration 21:  log likelihood = -54.627618
   Iteration 22:  log likelihood = -54.627612
   Iteration 23:  log likelihood = -54.627609
   Iteration 24:  log likelihood = -54.627607
   Iteration 25:  log likelihood = -54.627605
```

```
                                                Number of obs     =        130
                                                Wald chi2(4)      =      16.34
Log likelihood = -54.627605                     Prob > chi2       =     0.0026
```

y	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
x1	.4833318	.1542635	3.13	0.002	.180981	.7856827
x2	1.453275	.597925	2.43	0.015	.2813639	2.625187
x3	2.172641	.8589781	2.53	0.011	.489075	3.856207
x4	1.854961	.7142729	2.60	0.009	.4550117	3.25491
_cons	-1.400063	.5625155	-2.49	0.013	-2.502573	-.2975527

```
14 . do "C:\Users\PONGPA~1\AppData\Local\Temp\STD00000000.tmp"

15 . program ml_probit
  1.  args lnf theta
  2.  tempvar z
  3.  quietly g double `z'=`theta'
  4.  quietly replace `lnf'=ln(normal(`z')) if $ML_y1==1
  5.  quietly replace `lnf'=ln(1-normal(`z')) if $ML_y1==0
  6. end

16 .
end of do-file

17 . ml model lf ml_probit (y= x1 x2)

18 . ml max

initial:       log likelihood = -90.109133
alternative:   log likelihood = -87.504336
rescale:       log likelihood = -86.291737
Iteration 0:   log likelihood = -86.291737
Iteration 1:   log likelihood = -78.555778
Iteration 2:   log likelihood = -65.283109
Iteration 3:   log likelihood = -60.757413
Iteration 4:   log likelihood = -60.695535
Iteration 5:   log likelihood = -60.695503
Iteration 6:   log likelihood = -60.695503

                                                Number of obs     =        130
                                                Wald chi2(2)      =      22.61
Log likelihood = -60.695503                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
x1	.3592444	.0871351	4.12	0.000	.1884627	.5300262
x2	1.139607	.3224845	3.53	0.000	.5075491	1.771665
_cons	-.7729211	.2765064	-2.80	0.005	-1.314864	-.2309785

```
19 . do "C:\Users\PONGPA~1\AppData\Local\Temp\STD00000000.tmp"

20 . program ml_probit_het
  1.  args lnf theta sigma
  2.  tempvar z s
  3.  quietly g double `s'=exp(`sigma')
  4.  quietly g double `z'=`theta'/`s'
  5.  quietly replace `lnf'=ln(normal(`z')) if $ML_y1==1
  6.  quietly replace `lnf'=ln(1-normal(`z')) if $ML_y1==0
  7. end

21 .
end of do-file

22 .  ml model lf ml_probit_het (y= x1 x2) (x4,nonconstant)

23 . ml max

initial:        log likelihood = -90.109133
alternative:    log likelihood = -86.134146
rescale:        log likelihood = -86.134146
rescale eq:     log likelihood = -86.134146
Iteration 0:    log likelihood = -86.134146  (not concave)
Iteration 1:    log likelihood = -79.195811  (not concave)
Iteration 2:    log likelihood = -69.609905  (not concave)
Iteration 3:    log likelihood = -65.849718  (not concave)
Iteration 4:    log likelihood = -63.687373  (not concave)
Iteration 5:    log likelihood = -63.432877  (not concave)
Iteration 6:    log likelihood = -63.402502  (not concave)
Iteration 7:    log likelihood = -62.157013  (not concave)
Iteration 8:    log likelihood = -60.002562  (not concave)
Iteration 9:    log likelihood = -59.468511  (not concave)
Iteration 10:   log likelihood = -59.409964  (not concave)
Iteration 11:   log likelihood = -59.406069  (not concave)
Iteration 12:   log likelihood = -59.404566
Iteration 13:   log likelihood = -59.404456
Iteration 14:   log likelihood = -59.404451  (not concave)
Iteration 15:   log likelihood = -59.404451  (not concave)
Iteration 16:   log likelihood = -59.404451  (not concave)
Iteration 17:   log likelihood = -59.404451  (not concave)
Iteration 18:   log likelihood = -59.404451  (not concave)
Iteration 19:   log likelihood = -59.404451  (not concave)
Iteration 20:   log likelihood = -59.404451  (not concave)
Iteration 21:   log likelihood = -59.404451  (not concave)
Iteration 22:   log likelihood = -59.404451  (not concave)
Iteration 23:   log likelihood = -59.404451  (not concave)
Iteration 24:   log likelihood = -59.404451  (not concave)
Iteration 25:   log likelihood = -59.404451  (not concave)
Iteration 26:   log likelihood = -59.404451  (not concave)
Iteration 27:   log likelihood = -59.404451  (not concave)
Iteration 28:   log likelihood = -59.404451  (not concave)
Iteration 29:   log likelihood = -59.404451  (not concave)
Iteration 30:   log likelihood = -59.404451  (not concave)
Iteration 31:   log likelihood = -59.404451  (not concave)
Iteration 32:   log likelihood = -59.404451  (not concave)
Iteration 33:   log likelihood = -59.404451  (not concave)
Iteration 34:   log likelihood = -59.404451  (not concave)
Iteration 35:   log likelihood = -59.404451  (not concave)
Iteration 36:   log likelihood = -59.404451  (not concave)
Iteration 37:   log likelihood = -59.404451  (not concave)
Iteration 38:   log likelihood = -59.404451  (not concave)
Iteration 39:   log likelihood = -59.404451  (not concave)
Iteration 40:   log likelihood = -59.404451  (not concave)
Iteration 41:   log likelihood = -59.404451  (not concave)
Iteration 42:   log likelihood = -59.404451  (not concave)
Iteration 43:   log likelihood = -59.404451  (not concave)
Iteration 44:   log likelihood = -59.404451  (not concave)
```

```
Iteration 313: log likelihood = -59.404451  (not concave)
Iteration 314: log likelihood = -59.404451  (not concave)
Iteration 315: log likelihood = -59.404451  (not concave)
Iteration 316: log likelihood = -59.404451  (not concave)
Iteration 317: log likelihood = -59.404451  (not concave)
Iteration 318: log likelihood = -59.404451  (not concave)
Iteration 319: log likelihood = -59.404451  (not concave)
Iteration 320: log likelihood = -59.404451  (not concave)
Iteration 321: log likelihood = -59.404451  (not concave)
Iteration 322: log likelihood = -59.404451  (not concave)
--Break--
r(1);

24 . ml model lf ml_probit_het (y= x1 x2) (x4,noconstant)

25 . ml max

initial:       log likelihood = -90.109133
alternative:   log likelihood = -83.932039
rescale:       log likelihood = -83.932039
rescale eq:    log likelihood =  -70.42663
Iteration 0:   log likelihood =  -70.42663
Iteration 1:   log likelihood = -69.416401
Iteration 2:   log likelihood = -67.899496
Iteration 3:   log likelihood = -64.606934
Iteration 4:   log likelihood = -62.796305  (not concave)
Iteration 5:   log likelihood = -59.740391
Iteration 6:   log likelihood = -59.425613
Iteration 7:   log likelihood = -59.404517
Iteration 8:   log likelihood = -59.404451
Iteration 9:   log likelihood = -59.404451

                                                Number of obs     =        130
                                                Wald chi2(2)      =      16.42
Log likelihood = -59.404451                     Prob > chi2       =     0.0003

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
eq1          |
          x1 |   .2921402   .0773776     3.78   0.000      .140483    .4437975
          x2 |   .9417318   .2800571     3.36   0.001       .39283    1.490634
       _cons |  -.6388431   .2144267    -2.98   0.003    -1.059112   -.2185745
-------------+----------------------------------------------------------------
eq2          |
          x4 |   1.183929   .5851992     2.02   0.043     .0369597    2.330899
------------------------------------------------------------------------------

26 . est store ur_het

27 .  ml model lf ml_probit_het (y=) (x4,noconstant)

28 . ml max

initial:       log likelihood = -90.109133
alternative:   log likelihood = -83.932039
rescale:       log likelihood = -83.932039
rescale eq:    log likelihood =  -70.42663
Iteration 0:   log likelihood =  -70.42663
Iteration 1:   log likelihood = -69.976275
Iteration 2:   log likelihood = -69.973883
Iteration 3:   log likelihood = -69.973882

                                                Number of obs     =        130
                                                Wald chi2(0)      =          .
Log likelihood = -69.973882                     Prob > chi2       =          .
```

y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
eq1						
_cons	**.6158099**	**.2005698**	**3.07**	**0.002**	**.2227003**	**1.008919**
eq2						
x4	**-8.17863**	**3.212406**	**-2.55**	**0.011**	**-14.47483**	**-1.882429**

```
29 . est store res_het

30 . lrtest yr_het res_het
   estimation result yr_het not found
   r(111);

31 . lrtest ur_het res_het

   Likelihood-ratio test                                 LR chi2(2)  =     21.14
   (Assumption: res_het nested in ur_het)                Prob > chi2 =    0.0000

32 . log close
         name:  <unnamed>
          log:  C:\Users\Pongpanot\Downloads\fixed ASS4_MLE.smcl
     log type:  smcl
    closed on:  18 Feb 2021, 01:47:43
```