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.

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

y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
x1	.4835128	.1686119	2.87	0.004	.1530395	.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

$$z = -1.4004 + .4835128x_1 + 1.454X_2 + 2.1732X_3 + 1.8555x_4$$

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

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

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

From the test, p-value is 0.0001. Hence, H_0 is rejected.

LR

Wald

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

Wald-test, p-value is 0.000. Hence, H_0 is rejected.

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?

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

$$z = -1.40006 + .4833x_1 + 1.4533x_2 + 2.1726x_3 + 1.855x_4$$

The result is different due to different iterative procedure give different result.

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

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

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

$$z_1 = -.7729 + .3592x_1 + 1.1396x_2$$

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

y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
eq1						
x1	.0789287	8.652144	0.01	0.993	-16.87896	17.03682
x2	.2544314	27.89071	0.01	0.993	-54.41036	54.91923
_cons	-.1725989	18.92029	-0.01	0.993	-37.25568	36.91048
eq2						
x4	1.18393	.5852007	2.02	0.043	.0369574	2.330902
_cons	-1.308686	109.62	-0.01	0.990	-216.1599	213.5425

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

P-value is 0.000, H_0 is rejected.

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



```
1 . log using "C:\Users\Jilllin\OneDrive\Desktop\Thammasat\EE426\As4.smcl", replace
------------------------------------------------------------------------------------
      name:  <unnamed>
       log:  C:\Users\Jilllin\OneDrive\Desktop\Thammasat\EE426\As4.smcl
  log type:  smcl
 opened on:  17 Feb 2021, 23:23:10

2 . use "C:\Users\Jilllin\OneDrive\Desktop\Thammasat\EE426\Data\assign4.dta"

3 . 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

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

5 . ml maximize

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 = -63.355226
Iteration 3:   log likelihood = -57.763041
Iteration 4:   log likelihood = -55.063873
Iteration 5:   log likelihood = -54.628535
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	.1530395	.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=x1 x2 x3 x4)

 9 . ml model lf ml_logit (y=)

10 . ml maximize

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

```
11 . est store res

12 . lrtest ur res

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

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

14 . ml maximize

   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

```
15 . program ml_probit
  1.
```

```
16 .  args lnf theta
    2.
17 .  tempvar z
    3.
18 .  quietly g double `z'=`theta'
    4.
19 .  quietly replace `lnf'=ln(normal(`z')) if $ML_y1==1
    5.
20 .  quietly replace `lnf'=ln(1-normal(`z')) if $ML_y1==0
    6.
21 . end

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

23 . ml maximize

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 = -65.283096
Iteration 3:   log likelihood =  -60.75495
Iteration 4:   log likelihood = -60.695531
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

```
24 . program ml_probit_het
    1.
25 .  args lnf theta sigma
    2.
26 .  tempvar z s
    3.
27 .  quietly g double `s'=exp(`sigma')
    4.
28 .  quietly g double `z'=`theta'/`s'
    5.
29 .  quietly replace `lnf'=ln(normal(`z')) if $ML_y1==1
    6.
```

```
30 .  quietly replace `lnf'=ln(1-normal(`z')) if $ML_y1==0
   7.
31 . end

32 . ml model lf ml_probit_het (y=x1 x2) (x4, no constant)

33 . ml maximize

   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 = -69.612301  (not concave)
   Iteration 3:   log likelihood =  -65.86911  (not concave)
   Iteration 4:   log likelihood = -63.667358  (not concave)
   Iteration 5:   log likelihood = -63.423552  (not concave)
   Iteration 6:   log likelihood = -63.399443  (not concave)
   Iteration 7:   log likelihood = -63.379215  (not concave)
   Iteration 8:   log likelihood = -63.363234  (not concave)
   Iteration 9:   log likelihood = -63.349733  (not concave)
   Iteration 10:  log likelihood = -63.338351  (not concave)
   Iteration 11:  log likelihood = -63.328032  (not concave)
   Iteration 12:  log likelihood = -63.319081  (not concave)
   Iteration 13:  log likelihood = -63.310161  (not concave)
   Iteration 14:  log likelihood =  -63.30152  (not concave)
   Iteration 15:  log likelihood =  -63.29265  (not concave)
   Iteration 16:  log likelihood = -63.283142  (not concave)
   Iteration 17:  log likelihood = -63.272573  (not concave)
   Iteration 18:  log likelihood = -63.252925  (not concave)
   Iteration 19:  log likelihood = -62.313452  (not concave)
   Iteration 20:  log likelihood =  -59.70874  (not concave)
   Iteration 21:  log likelihood =  -59.42149  (not concave)
   Iteration 22:  log likelihood = -59.407105  (not concave)
   Iteration 23:  log likelihood = -59.405108  (not concave)
   Iteration 24:  log likelihood = -59.404498
   Iteration 25:  log likelihood = -59.404451  (not concave)
   Iteration 26:  log likelihood = -59.404451  (backed up)

                                                   Number of obs     =        130
                                                   Wald chi2(2)      =       0.00
   Log likelihood = -59.404451                     Prob > chi2       =     1.0000

   ------------------------------------------------------------------------------
              y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
   -------------+----------------------------------------------------------------
   eq1          |
             x1 |   .0789287   8.652144     0.01   0.993    -16.87896    17.03682
             x2 |   .2544314   27.89071     0.01   0.993    -54.41036    54.91923
          _cons |  -.1725989   18.92029    -0.01   0.993    -37.25568    36.91048
   -------------+----------------------------------------------------------------
   eq2          |
             x4 |    1.18393   .5852007     2.02   0.043     .0369574    2.330902
          _cons |  -1.308686     109.62    -0.01   0.990    -216.1599    213.5425
   ------------------------------------------------------------------------------
```

```
34 . est store ur_het

35 . ml model lf ml_probit _het (y= ) (x4, no constant)
   variable _het not found
   r(111);

36 . ml model lf ml_probit_het (y= ) (x4, no constant)

37 . ml maximize

   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 = -79.195968  (not concave)
   Iteration 2:   log likelihood =  -70.81196  (not concave)
   Iteration 3:   log likelihood = -70.067642  (not concave)
   Iteration 4:   log likelihood =  -69.98155  (not concave)
   Iteration 5:   log likelihood =  -69.97421
   Iteration 6:   log likelihood = -69.973882  (not concave)
   Iteration 7:   log likelihood = -69.973882  (backed up)

                                                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	.6579989	27.13016	0.02	0.981	-52.51614	53.83214
eq2						
x4	-8.178492	3.212421	-2.55	0.011	-14.47472	-1.882262
_cons	.0662995	41.2326	0.00	0.999	-80.74811	80.88071

```
38 . est store res_het

39 . lrtest ur_het res_het

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

40 . log close
         name:  <unnamed>
          log:  C:\Users\Jilllin\OneDrive\Desktop\Thammasat\EE426\As4.smcl
     log type:  smcl
    closed on:  17 Feb 2021, 23:40:51

41 .
```