Assignment 4

From the data set `assign4.dta`:

The study on bankruptcy firm employs the following regression model.

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

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

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

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

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 Φ(.) = Cumulation standard normal probability distribution function and

$$z_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} \quad (3)$$

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,
Φ(.) = 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.

```
                                                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	.4737577	2.43426
x3	2.173186	.7757021	2.80	0.005	.6528381	3.693535
x4	1.855464	.7138855	2.60	0.009	.4562739	3.254653
_cons	-1.400447	.5531237	-2.53	0.011	-2.484549	-.316344

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

```
. 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
```

∴ reject H_0 at 1% level.

```
. lrtest ur res

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

∴ reject H_0 at 1% level, the model is significant.

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?

```
                                                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

The coefficients are different from the first model by only a little bit, however, the X_2 and X_3 become insignificant at 5% level. This is caused the change in algorith that we use to calculate for the coefficients

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

```
                                                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

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

```
                                                Number of obs     =        130
                                                Wald chi2(2)      =       0.00
Log likelihood = -59.404451                     Prob > chi2       =     0.9998
```

y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
eq1						
x1	.0395851	2.109128	0.02	0.985	-4.094229	4.173399
x2	.1276046	6.798863	0.02	0.985	-13.19792	13.45313
_cons	-.0865638	4.612226	-0.02	0.985	-9.12636	8.953232
eq2						
x4	1.183922	.5852076	2.02	0.043	.0369358	2.330907
_cons	-1.998771	53.28114	-0.04	0.970	-106.4279	102.4303

```
. lrtest ur_het res_het

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

∴ Reject H_0 at 1% significant level. The model has heteroskedasticity problem.

```
  ___  ____  ____  ____  ____ (R)
 /__    /   ____/   /   ____/
___/   /   /___/   /   /___/   14.0   Copyright 1985-2015 StataCorp LP
  Statistics/Data Analysis            StataCorp
                                      4905 Lakeway Drive
     MP - Parallel Edition            College Station, Texas 77845 USA
                                      800-STATA-PC          http://www.stata.com
                                      979-696-4600          stata@stata.com
                                      979-696-4601 (fax)

Single-user 8-core Stata perpetual license:
       Serial number:  10699393
         Licensed to:  T


Notes:
      1.  Unicode is supported; see   help unicode_advice .
      2.  More than 2 billion observations are allowed; see     help obs_advice_.
      3.  Maximum number of variables is set to 5000; see     help set_maxvar .

. use "C:\Users\USER\Desktop\assign4.dta", clear

. do "C:\Users\USER\AppData\Local\Temp\STD00000000.tmp"

. 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

.
end of do-file

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

. 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 =   -63.354154
Iteration 3:   log likelihood =   -57.771658
Iteration 4:   log likelihood =   -55.050008
Iteration 5:   log likelihood =   -54.628663
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	.4737577	2.43426
x3	2.173186	.7757021	2.80	0.005	.6528381	3.693535
x4	1.855464	.7138855	2.60	0.009	.4562739	3.254653
_cons	-1.400447	.5531237	-2.53	0.011	-2.484549	-.316344

```
. 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

. est store ur

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

. ml model lf ml_logit (y=)

. 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
------------------------------------------------------------------------------

. estimate store res

. lrtest ur res

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

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

. 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

```
. do "C:\Users\USER\AppData\Local\Temp\STD00000000.tmp"

. 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

.
end of do-file

. ml model lf ml_probit (y=x1 x2)

. 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 =    -65.28309
Iteration 3:   log likelihood =   -60.749729
Iteration 4:   log likelihood =   -60.695526
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

```
. do "C:\Users\USER\AppData\Local\Temp\STD00000000.tmp"

. 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
```

```
.
end of do-file

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

. 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 =   -69.598342  (not concave)
Iteration 3:   log likelihood =    -65.82747  (not concave)
Iteration 4:   log likelihood =   -63.703903  (not concave)
Iteration 5:   log likelihood =   -63.438161
Iteration 6:   log likelihood =   -63.297658  (not concave)
Iteration 7:   log likelihood =   -63.229822  (not concave)
Iteration 8:   log likelihood =   -61.936077  (not concave)
Iteration 9:   log likelihood =   -59.839419
Iteration 10:  log likelihood =   -59.504769
Iteration 11:  log likelihood =   -59.406567  (not concave)
Iteration 12:  log likelihood =   -59.404629
Iteration 13:  log likelihood =   -59.404451  (not concave)
Iteration 14:  log likelihood =   -59.404451  (backed up)

                                              Number of obs     =            130
                                              Wald chi2(    2)  =           0.00
Log likelihood =  -59.404451                  Prob > chi2       =         0.9998

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
eq1          |
          x1 |   .0395851   2.109128     0.02   0.985    -4.094229    4.173399
          x2 |   .1276046   6.798863     0.02   0.985    -13.19792    13.45313
       _cons |  -.0865638   4.612226    -0.02   0.985     -9.12636    8.953232
-------------+----------------------------------------------------------------
eq2          |
          x4 |   1.183922   .5852076     2.02   0.043     .0369358    2.330907
       _cons |  -1.998771   53.28114    -0.04   0.970    -106.4279    102.4303
------------------------------------------------------------------------------

. est store ur_het

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

. 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 =   -70.811774  (not concave)
Iteration 3:   log likelihood =   -70.066405  (not concave)
Iteration 4:   log likelihood =   -69.980922  (not concave)
Iteration 5:   log likelihood =   -69.974419
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	**.6569098**	**27.55731**	**0.02**	**0.981**	**-53.35443**	**54.66825**
eq2						
x4	**-8.178284**	**3.212271**	**-2.55**	**0.011**	**-14.47422**	**-1.882348**
_cons	**.0646295**	**41.95118**	**0.00**	**0.999**	**-82.15818**	**82.28744**

```
. est res_het
subcommand estimates res_het is unrecognized
r(198);

. est store res_het

. lrtest ur_het res_het

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

.
```