

BOSTON COLLEGE
 Department of Economics
 EC 771: Econometrics
 Spring 2009
 Prof. Baum, Ms. Skira

PROBLEM SET 6: SOLUTIONS

Point Distribution:
 1), 2), 5): 15 points each
 3), 4): 20 points each

1) a)

```
. use ~/Documents/Economics/data/grunfeld
```

```
. xtreg invest mvalue kstock, fe
```

```
Fixed-effects (within) regression      Number of obs      =      200
Group variable (i): company            Number of groups   =       10

R-sq:  within = 0.7668                  Obs per group: min =       20
      between = 0.8194                      avg =      20.0
      overall  = 0.8060                      max =       20

corr(u_i, Xb) = -0.1517                  F(2,188)           =    309.01
                                          Prob > F           =     0.0000
```

invest	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
mvalue	.1101238	.0118567	9.29	0.000	.0867345	.1335131
kstock	.3100653	.0173545	17.87	0.000	.2758308	.3442999
_cons	-58.74393	12.45369	-4.72	0.000	-83.31086	-34.177
sigma_u	85.732501					
sigma_e	52.767964					
rho	.72525012	(fraction of variance due to u_i)				

```
F test that all u_i=0:      F(9, 188) =    49.18      Prob > F = 0.0000
```

```
. est store xfe
```

```
. xtreg invest mvalue kstock
```

```

Random-effects GLS regression                Number of obs    =      200
Group variable (i): company                 Number of groups  =       10

R-sq:  within = 0.7668                      Obs per group:  min =       20
        between = 0.8196                      avg =          20.0
        overall = 0.8061                      max =          20

Random effects u_i ~ Gaussian              Wald chi2(2)     =    657.67
corr(u_i, X) = 0 (assumed)                 Prob > chi2      =    0.0000

```

```

-----+-----
      invest |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----+-----
      mvalue |   .1097811   .0104927    10.46  0.000   .0892159   .1303464
      kstock |   .3081113   .0171805    17.93  0.000   .2744399   .3417861
       _cons |  -57.83441   28.89893    -2.00  0.045  -114.4753  -1.193537
-----+-----
      sigma_u |   84.20095
      sigma_e |   52.767964
         rho |   .71800838   (fraction of variance due to u_i)
-----+-----

```

```

. est store xre

. hausman xfe xre

```

```

-----+-----
          ---- Coefficients ----
          |      (b)      (B)      (b-B)      sqrt(diag(V_b-V_B))
          |      xfe      xre      Difference      S.E.
-----+-----
      mvalue |   .1101238   .1097811   .0003427   .0055213
      kstock |   .3100653   .3081113   .0019524   .0024516
-----+-----

```

```

          b = consistent under Ho and Ha; obtained from xtreg
          B = inconsistent under Ha, efficient under Ho; obtained from xtreg

```

```

Test:  Ho:  difference in coefficients not systematic

```

$$\begin{aligned}
\text{chi2}(2) &= (b-B)'[(V_b-V_B)^{-1}](b-B) \\
&= 2.33 \\
\text{Prob}>\text{chi2} &= 0.3119
\end{aligned}$$

Rejection of the null hypothesis would indicate that the RE estimator was inconsistent. Since the null hypothesis

is not rejected, the RE estimator is appropriate and preferred due to its efficiency.

b)

```
. drop _est*

.
. tsset year company
    panel variable:  year (strongly balanced)
    time variable:   company, 1 to 10

. xi i.company
i.company          _Icompany_1-10      (naturally coded; _Icompany_1 omitted)

. xtreg invest mvalue kstock _Icompany_2 _Icompany_3 _Icompany_4 _Icompany_5 ///
>    _Icompany_6 _Icompany_7 _Icompany_8 _Icompany_9 _Icompany_10, fe
```

```
Fixed-effects (within) regression                Number of obs   =       200
Group variable (i): year                        Number of groups =        20

R-sq:  within = 0.9482                          Obs per group: min =         10
        between = 0.9379                          avg =           10.0
        overall = 0.9416                          max =           10

corr(u_i, Xb) = -0.2617                          F(11,169)       =       281.32
                                                Prob > F        =       0.0000
```

invest	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
mvalue	.1177158	.0137513	8.56	0.000	.0905694	.1448623
kstock	.3579163	.022719	15.75	0.000	.3130667	.4027659
_Icompany_2	207.0542	35.17275	5.89	0.000	137.6197	276.4887
_Icompany_3	-135.2308	35.70897	-3.79	0.000	-205.7239	-64.73772
_Icompany_4	95.3538	50.72211	1.88	0.062	-4.776741	195.4844
_Icompany_5	-5.438636	57.83052	-0.09	0.925	-119.6019	108.7246
_Icompany_6	102.8886	54.17388	1.90	0.059	-4.056071	209.8333
_Icompany_7	51.46657	58.17922	0.88	0.378	-63.38505	166.3182
_Icompany_8	67.49048	50.97092	1.32	0.187	-33.13125	168.1122
_Icompany_9	30.21752	55.72307	0.54	0.588	-79.78542	140.2204
_Icompany_10	126.8371	58.52545	2.17	0.032	11.30197	242.3722
_cons	-134.2277	58.29153	-2.30	0.023	-249.301	-19.15433
sigma_u	23.128818					
sigma_e	51.724523					
rho	.16662954	(fraction of variance due to u_i)				

```
F test that all u_i=0:      F(19, 169) =      1.40          Prob > F = 0.1309
```

```
. drop _I*
```

```
. tsset company year
    panel variable:  company (strongly balanced)
    time variable:  year, 1935 to 1954
```

To avoid having twenty year dummies, I swapped the group and time indices, created dummies for the companies, and ran the fixed effects estimator. The estimates for mvalue and kstock aren't changed very much.

c)

```
. reshape wide invest mvalue kstock time, i(year) j(company)
(note: j = 1 2 3 4 5 6 7 8 9 10)
```

```
Data                long  ->  wide
-----
Number of obs.      200  ->   20
Number of variables    6  ->   41
j variable (10 values) company -> (dropped)
xij variables:
    invest  ->  invest1 invest2 ... invest10
    mvalue  ->  mvalue1 mvalue2 ... mvalue10
    kstock  ->  kstock1 kstock2 ... kstock10
    time    ->  time1  time2 ... time10
```

```
. sureg (invest1 mvalue1 kstock1) (invest2 mvalue2 kstock2) (invest3 mvalue3 kstock3) ///
> (invest4 mvalue4 kstock4) (invest5 mvalue5 kstock5) (invest6 mvalue6 kstock6) ///
> (invest7 mvalue7 kstock7) (invest8 mvalue8 kstock8) (invest9 mvalue9 kstock9) ///
> (invest10 mvalue10 kstock10)
```

Seemingly unrelated regression

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
invest1	20	2	85.01269	0.9206	284.94	0.0000
invest2	20	2	89.33556	0.4658	32.76	0.0000
invest3	20	2	26.59842	0.6845	51.78	0.0000
invest4	20	2	12.41115	0.9112	208.80	0.0000
invest5	20	2	8.465161	0.6721	38.24	0.0000
invest6	20	2	7.640396	0.9497	447.97	0.0000
invest7	20	2	8.739524	0.7603	80.10	0.0000
invest8	20	2	9.837619	0.7210	77.06	0.0000

invest9	20	2	8.516405	0.6552	40.80	0.0000
invest10	20	2	1.029905	0.6220	43.88	0.0000

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

invest1						
mvalue1	.1138135	.0167455	6.80	0.000	.0809928	.1466342
kstock1	.3861235	.0297382	12.98	0.000	.3278378	.4444092
_cons	-135.6061	72.29358	-1.88	0.061	-277.2989	6.086716

invest2						
mvalue2	.1627658	.0401126	4.06	0.000	.0841465	.2413851
kstock2	.3406261	.1016225	3.35	0.001	.1414497	.5398026
_cons	-10.90599	82.50626	-0.13	0.895	-172.6153	150.8033

invest3						
mvalue3	.0349626	.009346	3.74	0.000	.0166448	.0532803
kstock3	.1257302	.020424	6.16	0.000	.0856998	.1657605
_cons	-15.8959	20.73065	-0.77	0.443	-56.52724	24.73543

invest4						
mvalue4	.0678437	.0159811	4.25	0.000	.0365213	.0991661
kstock4	.3075528	.0253627	12.13	0.000	.2578428	.3572628
_cons	1.804334	11.0026	0.16	0.870	-19.76036	23.36903

invest5						
mvalue5	.1274473	.0458318	2.78	0.005	.0376187	.2172759
kstock5	.0119871	.0179203	0.67	0.504	-.0231361	.0471104
_cons	26.46736	6.065146	4.36	0.000	14.57989	38.35483

invest6						
mvalue6	.1333107	.0177916	7.49	0.000	.0984398	.1681817
kstock6	.0540052	.0597388	0.90	0.366	-.0630806	.1710911
_cons	-6.193452	3.439334	-1.80	0.072	-12.93442	.5475189

invest7						
mvalue7	.1134649	.0457163	2.48	0.013	.0238627	.2030671
kstock7	.1281802	.0146209	8.77	0.000	.0995238	.1568367
_cons	-9.770128	8.763982	-1.11	0.265	-26.94722	7.406962

invest8						
mvalue8	.0537015	.0082648	6.50	0.000	.0375027	.0699002
kstock8	.0433622	.0345859	1.25	0.210	-.0244249	.1111494
_cons	3.149101	5.056158	0.62	0.533	-6.760786	13.05899

invest9							
mvalue9		.0765949	.0210567	3.64	0.000	.0353245	.1178654
kstock9		.0654245	.0219503	2.98	0.003	.0224027	.1084463
_cons		-3.156863	7.29719	-0.43	0.665	-17.45909	11.14537

invest10							
mvalue10		-.0161291	.0157461	-1.02	0.306	-.0469909	.0147327
kstock10		.3768475	.0573058	6.58	0.000	.2645303	.4891647
_cons		1.98935	1.177681	1.69	0.091	-.3188624	4.297562

```
. test [invest1]mvalue1 = [invest2]mvalue2 = [invest3]mvalue3 = [invest4]mvalue4 = ///
>      [invest5]mvalue5 = [invest6]mvalue6 = [invest7]mvalue7 = [invest8]mvalue8 = ///
>      [invest9]mvalue9 = [invest10]mvalue10
```

- (1) [invest1]mvalue1 - [invest2]mvalue2 = 0
- (2) [invest1]mvalue1 - [invest3]mvalue3 = 0
- (3) [invest1]mvalue1 - [invest4]mvalue4 = 0
- (4) [invest1]mvalue1 - [invest5]mvalue5 = 0
- (5) [invest1]mvalue1 - [invest6]mvalue6 = 0
- (6) [invest1]mvalue1 - [invest7]mvalue7 = 0
- (7) [invest1]mvalue1 - [invest8]mvalue8 = 0
- (8) [invest1]mvalue1 - [invest9]mvalue9 = 0
- (9) [invest1]mvalue1 - [invest10]mvalue10 = 0

```
      chi2( 9) =    79.36
      Prob > chi2 =    0.0000
```

```
. test [invest1]kstock1 = [invest2]kstock2 = [invest3]kstock3 = [invest4]kstock4 = ///
>      [invest5]kstock5 = [invest6]kstock6 = [invest7]kstock7 = [invest8]kstock8 = ///
>      [invest9]kstock9 = [invest10]kstock10
```

- (1) [invest1]kstock1 - [invest2]kstock2 = 0
- (2) [invest1]kstock1 - [invest3]kstock3 = 0
- (3) [invest1]kstock1 - [invest4]kstock4 = 0
- (4) [invest1]kstock1 - [invest5]kstock5 = 0
- (5) [invest1]kstock1 - [invest6]kstock6 = 0
- (6) [invest1]kstock1 - [invest7]kstock7 = 0
- (7) [invest1]kstock1 - [invest8]kstock8 = 0
- (8) [invest1]kstock1 - [invest9]kstock9 = 0
- (9) [invest1]kstock1 - [invest10]kstock10 = 0

```
      chi2( 9) =   318.07
      Prob > chi2 =    0.0000
```

SUR allows each company to have its own coefficient vector, whereas fixed effects only allows the constant term to vary. Furthermore, the error structure is richer with SUR; each company can have a different error variance.

The test for cross-equation equality for each of the slope coefficients is rejected, indicating heterogeneity across companies.

2) a)

```
. use ~/Documents/Economics/data/pntsprd.dta
. reg favwin spread, robust
```

```
Linear regression                Number of obs =      553
                                F( 1, 551) = 101.54
                                Prob > F      = 0.0000
                                R-squared      = 0.1107
                                Root MSE    = .40168
```

	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
favwin						
spread	.0193655	.0019218	10.08	0.000	.0155905	.0231405
_cons	.5769492	.0316568	18.23	0.000	.5147664	.6391321

```
. test _cons == 0.5
```

(1) _cons = .5

```
F( 1, 551) = 5.91
Prob > F = 0.0154
```

```
. lincom _cons + 10*spread
```

(1) 10 spread + _cons = 0

	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
(1)	.7706044	.0166574	46.26	0.000	.7378847	.8033241

If spread incorporates all the relevant information, then when the spread is zero, there is no information that would indicate whether one or the other team is more likely to win and so the probability of winning is 0.5. Yes, the coefficient on spread is highly statistically significantly different from 0. The estimated probability of a win

given a spread of 10 is 0.77.

b)

```
. probit favwin spread
```

```
Iteration 0:  log likelihood = -302.74988
Iteration 1:  log likelihood = -266.49244
Iteration 2:  log likelihood = -263.62542
Iteration 3:  log likelihood = -263.56223
Iteration 4:  log likelihood = -263.56219
```

```
Probit regression                               Number of obs =          553
                                                LR chi2(1)      =          78.38
                                                Prob > chi2     =          0.0000
Log likelihood = -263.56219                    Pseudo R2      =          0.1294
```

favwin	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
spread	.092463	.0121811	7.59	0.000	.0685885 .1163374
_cons	-.0105926	.1037469	-0.10	0.919	-.2139328 .1927476

```
. test _cons
```

```
( 1)  _cons = 0
```

```
      chi2( 1) =    0.01
      Prob > chi2 =    0.9187
```

```
. nlcom normal(_b[_cons] + 10*_b[spread])
```

```
      _nl_1:  normal(_b[_cons] + 10*_b[spread])
```

favwin	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
_nl_1	.8196513	.0194412	42.16	0.000	.7815473 .8577553

```
. mfx, at (spread = 10)
```

```
Marginal effects after probit
      y = Pr(favwin) (predict)
      = .81965134
```


variable	dy/dx	Std. Err.	z	P> z	[95% C.I.]	X
spread	.0242918	.00271	8.95	0.000	.018971 .029613	10

When the intercept is zero and spread is zero, the probability is 0.5. So, we see again the reasoning in part a) that the intercept should reflect whether spread incorporates all relevant information. Using the probit model, we cannot reject the hypothesis that spread incorporates all relevant information, which we could using the linear probability model. The estimated probability using the probit model is 0.82 when spread is 10. The marginal effect is 0.024.

c)

```
. probit favwin spread favhome fav25 und25
```

```
Iteration 0: log likelihood = -302.74988
Iteration 1: log likelihood = -265.47417
Iteration 2: log likelihood = -262.70317
Iteration 3: log likelihood = -262.64181
Iteration 4: log likelihood = -262.64177
```

```
Probit regression                               Number of obs =          553
                                                LR chi2(4)          =          80.22
                                                Prob > chi2         =          0.0000
Log likelihood = -262.64177                    Pseudo R2          =          0.1325
```

favwin	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
spread	.0878845	.0129491	6.79	0.000	.0625047 .1132642
favhome	.1485753	.1370571	1.08	0.278	-.1200517 .4172024
fav25	.003068	.15869	0.02	0.985	-.3079587 .3140946
und25	-.2198082	.2505842	-0.88	0.380	-.7109443 .2713278
_cons	-.0551801	.128763	-0.43	0.668	-.3075509 .1971907

```
. test favhome = fav25 = und25 = 0
```

- (1) favhome - fav25 = 0
- (2) favhome - und25 = 0
- (3) favhome = 0

```
chi2( 3) = 1.84
Prob > chi2 = 0.6054
```

The test reveals that the coefficients of the additional variables is not statistically significantly different from zero, which means we cannot reject the hypothesis that spread incorporates all relevant information.

3) a)

```
. use ~/Documents/Economics/data/loanapp.dta
```

```
. probit approve white
```

```
Iteration 0:  log likelihood = -740.34659
Iteration 1:  log likelihood = -701.33221
Iteration 2:  log likelihood = -700.87747
Iteration 3:  log likelihood = -700.87744
```

```
Probit regression                                Number of obs =      1989
                                                LR chi2(1)      =      78.94
                                                Prob > chi2     =      0.0000
Log likelihood = -700.87744                    Pseudo R2      =      0.0533
```

```
-----+-----
```

approve	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
white	.7839465	.0867118	9.04	0.000	.6139946	.9538984
_cons	.5469464	.075435	7.25	0.000	.3990964	.6947963

```
-----+-----
```

```
. // probit estimate of probability of approval if white
. nlcom normal(_b[_cons] + _b[white])
```

```
_nl_1: normal(_b[_cons] + _b[white])
```

```
-----+-----
```

approve	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
_nl_1	.9083879	.007036	129.10	0.000	.8945975	.9221782

```
-----+-----
```

```
. // probit estimate of probability of approval if black
. nlcom normal(_b[_cons])
```

```
_nl_1: normal(_b[_cons])
```

```
-----+-----
```

approve	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
_nl_1	.7077922	.0259133	27.31	0.000	.657003	.7585814

```
-----+-----
```

```
-----  
. reg approve white
```

Source	SS	df	MS	Number of obs =	1989
Model	10.4743407	1	10.4743407	F(1, 1987) =	102.23
Residual	203.59303	1987	.102462521	Prob > F =	0.0000
-----				R-squared =	0.0489
-----				Adj R-squared =	0.0485
Total	214.067371	1988	.107679764	Root MSE =	.3201

approve	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
white	.2005957	.01984	10.11	0.000	.1616864	.239505
_cons	.7077922	.0182393	38.81	0.000	.6720221	.7435623

```
-----  
. // linear model estimate of probability of approval if white  
. lincom _cons + white
```

```
( 1) white + _cons = 0
```

approve	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
(1)	.9083879	.0078073	116.35	0.000	.8930766	.9236991

```
-----  
. // linear model estimate of probability of approval if black  
. lincom _cons
```

```
( 1) _cons = 0
```

approve	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
(1)	.7077922	.0182393	38.81	0.000	.6720221	.7435623

The estimates of the probability of loan approval conditional on race from the probit model and the linear probability model are identical. There appears to be a strong effect of race on this probability.

b)

```
. probit approve white hrat obrat loanprc unem male married dep ///
```

```
> sch cosign chist pubrec mortlat1 mortlat2 vr
```

```
Iteration 0: log likelihood = -737.97933
Iteration 1: log likelihood = -604.00737
Iteration 2: log likelihood = -600.29775
Iteration 3: log likelihood = -600.27099
Iteration 4: log likelihood = -600.27099
```

```
Probit regression                                Number of obs =      1971
                                                LR chi2(15)    =      275.42
                                                Prob > chi2    =      0.0000
Log likelihood = -600.27099                    Pseudo R2     =      0.1866
```

approve	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
white	.5202525	.0969588	5.37	0.000	.3302168	.7102883
hrat	.0078763	.0069616	1.13	0.258	-.0057682	.0215209
obrat	-.0276924	.0060493	-4.58	0.000	-.0395488	-.015836
loanprc	-1.011969	.2372396	-4.27	0.000	-1.47695	-.5469882
unem	-.0366849	.0174807	-2.10	0.036	-.0709464	-.0024234
male	-.0370014	.1099273	-0.34	0.736	-.2524549	.1784521
married	.2657469	.0942523	2.82	0.005	.0810159	.4504779
dep	-.0495756	.0390573	-1.27	0.204	-.1261266	.0269753
sch	.0146496	.0958421	0.15	0.879	-.1731974	.2024967
cosign	.0860713	.2457509	0.35	0.726	-.3955917	.5677343
chist	.5852812	.0959715	6.10	0.000	.3971806	.7733818
pubrec	-.7787405	.12632	-6.16	0.000	-1.026323	-.5311578
mortlat1	-.1876236	.2531127	-0.74	0.459	-.6837153	.308468
mortlat2	-.4943562	.3265563	-1.51	0.130	-1.134395	.1456823
vr	-.2010621	.0814934	-2.47	0.014	-.3607862	-.041338
_cons	2.062327	.3131763	6.59	0.000	1.448512	2.676141

The coefficient on white is statistically significantly different from 0, which would indicate discrimination against nonwhites.

c)

```
. mfx, varlist(white)
```

```
Marginal effects after probit
y = Pr(approve) (predict)
= .91065604
```

variable	dy/dx	Std. Err.	z	P> z	[95% C.I.]	X
----------	-------	-----------	---	------	--------------	---

```
-----+-----
white*| .105747 .02386 4.43 0.000 .058988 .152506 .846271
-----+-----
```

(*) dy/dx is for discrete change of dummy variable from 0 to 1

```
. logit approve white hrat obrat loanprc unem male married dep ///
> sch cosign chist pubrec mortlat1 mortlat2 vr
```

```
Iteration 0: log likelihood = -737.97933
Iteration 1: log likelihood = -634.97536
Iteration 2: log likelihood = -601.41194
Iteration 3: log likelihood = -600.49724
Iteration 4: log likelihood = -600.49616
```

```
Logistic regression                                Number of obs =      1971
                                                    LR chi2(15)      =      274.97
                                                    Prob > chi2      =      0.0000
Log likelihood = -600.49616                       Pseudo R2       =      0.1863
```

```
-----+-----
approve |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----+-----
white   |   .9377643   .1729041     5.42  0.000    .5988784    1.27665
hrat    |   .0132631   .0128802     1.03  0.303   -.0119816    .0385078
obrat   |  -.0530338   .0112803    -4.70  0.000   -.0751427   -.0309249
loanprc |  -1.904951   .4604412    -4.14  0.000   -2.8074    -1.002503
unem    |  -.0665789   .0328086    -2.03  0.042   -.1308825   -.0022753
male    |  -.0663851   .2064288    -0.32  0.748   -.4709781    .3382078
married |   .5032817   .177998     2.83  0.005    .1544121    .8521513
dep     |  -.0907336   .0733341    -1.24  0.216   -.2344657    .0529986
sch     |   .0412287   .1784035     0.23  0.817   -.3084356    .3908931
cosign  |   .132059    .4460933     0.30  0.767   -.7422677    1.006386
chist   |   1.066577   .1712117     6.23  0.000    .731008    1.402146
pubrec  |  -1.340665   .2173657    -6.17  0.000   -1.766694   -.9146362
mortlat1 | -.3098821   .4635193    -0.67  0.504   -1.218363    .598599
mortlat2 | -.8946755   .5685807    -1.57  0.116   -2.009073    .2197222
vr      |  -.3498279   .1537248    -2.28  0.023   -.6511231   -.0485328
_cons   |   3.80171    .5947054     6.39  0.000    2.636109    4.967311
-----+-----
```

```
. mfx, varlist(white)
```

```
Marginal effects after logit
y = Pr(approve) (predict)
= .9141792
-----+-----
```

variable	dy/dx	Std. Err.	z	P> z	[95% C.I.]	X
white*	.0967431	.02249	4.30	0.000	.052659	.140828		.846271

(*) dy/dx is for discrete change of dummy variable from 0 to 1

The coefficient is markedly different, but a meaningful comparison of coefficients across logit and probit models cannot be made. However, the marginal effects can be compared. The probit model yields a larger marginal effect than does the logit model, but they are close in value.

d)

```
. qui probit approve white hrat obrat loanprc unem male married ///
>      dep sch cosign chist pubrec mortlat1 mortlat2 vr

. margeff
```

Average partial effects after probit
y = Pr(approve)

variable	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
white	.1042245	.0149126	6.99	0.000	.0749962 .1334527
hrat	.0013078	.0011553	1.13	0.258	-.0009566 .0035723
obrat	-.0045983	.0010014	-4.59	0.000	-.0065611 -.0026355
loanprc	-.1680353	.0392957	-4.28	0.000	-.2450534 -.0910172
unem	-.0060914	.0028994	-2.10	0.036	-.0117741 -.0004088
male	-.0060727	.018379	-0.33	0.741	-.0420948 .0299494
married	.0459954	.0141381	3.25	0.001	.0182853 .0737055
dep	-.0082333	.0064869	-1.27	0.204	-.0209474 .0044808
sch	.0024421	.0158594	0.15	0.878	-.0286417 .0335259
cosign	.0137141	.0374253	0.37	0.714	-.0596381 .0870662
chist	.1196853	.0145369	8.23	0.000	.0911936 .148177
pubrec	-.1804182	.0379961	-4.75	0.000	-.2548892 -.1059473
mortlat1	-.0340738	.050086	-0.68	0.496	-.1322406 .064093
mortlat2	-.1030246	.082264	-1.25	0.210	-.2642591 .0582099
vr	-.0339854	.0151069	-2.25	0.024	-.0635943 -.0043765

The estimate does not differ very much, but in principle could. Whereas the **mf** command calculates the marginal effect at the "average" individual, the **margeff** command determines the marginal effect for each individual, and then averages across each of these.

4) a)

```
. use ~/Documents/Economics/data/fringe.dta
```

```
. gen zeropen = 0
```

```
. replace zeropen = 1 if pension == 0  
(172 real changes made)
```

```
. reg zeropen
```

Source	SS	df	MS	Number of obs =	616
Model	0	0	.	F(0, 615) =	0.00
Residual	123.974026	615	.201583782	Prob > F =	.
Total	123.974026	615	.201583782	R-squared =	0.0000
				Adj R-squared =	0.0000
				Root MSE =	.44898

zeropen	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
_cons	.2792208	.01809	15.44	0.000	.2436952 .3147464

```
. summ pension if !zeropen
```

Variable	Obs	Mean	Std. Dev.	Min	Max
pension	444	905.0439	550.3696	7.28	2880.27

The pension is 0 for about 28% of the workers in the sample. The range of non-zero pensions is from 7.28 to 2880.27. The Tobit model is appropriate because we have censoring, since some workers might work at jobs that don't offer pension benefits rather than have no pension amount at jobs that do offer these benefits.

b)

```
. tobit pension exper age tenure educ depends married white male, ll(0)
```

Tobit regression	Number of obs =	616
	LR chi2(8) =	184.70
	Prob > chi2 =	0.0000
Log likelihood = -3672.9635	Pseudo R2 =	0.0245

pension	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
exper	5.203458	6.00928	0.87	0.387	-6.598007 17.00492
age	-4.638944	5.710741	-0.81	0.417	-15.85412 6.576228

tenure		36.02385	4.564348	7.89	0.000	27.06005	44.98765
educ		93.21262	10.89133	8.56	0.000	71.82343	114.6018
depends		35.28461	21.91691	1.61	0.108	-7.757432	78.32666
married		53.68858	71.73266	0.75	0.454	-87.18528	194.5624
white		144.0855	102.0753	1.41	0.159	-56.37738	344.5485
male		308.1505	69.8903	4.41	0.000	170.8948	445.4062
_cons		-1252.429	219.0692	-5.72	0.000	-1682.653	-822.2048

/sigma		677.7383	24.13815			630.3341	725.1426

Obs. summary: 172 left-censored observations at pension<=0
 444 uncensored observations
 0 right-censored observations

Males do have statistically significantly higher benefits than females, but whites do not.

c)

```
. mfx, predict(e(0,.)) at(white = 0 male = 0 age = 35 married = 0 depends = 0 ///
>       educ = 16 exper = 10)
```

warning: no value assigned in at() for variables tenure;
 means used for tenure

Marginal effects after tobit

y = E(pension|pension>0) (predict, e(0,.))
 = 718.46441

variable		dy/dx	Std. Err.	z	P> z	[95% C.I.]	X
exper		2.675663	3.04738	0.88	0.380	-3.2971 8.64842	10
age		-2.385385	2.90285	-0.82	0.411	-8.07486 3.30409	35
tenure		18.52377	3.12086	5.94	0.000	12.407 24.6405	7.75162
educ		47.93073	8.51085	5.63	0.000	31.2498 64.6117	16
depends		18.14365	11.07	1.64	0.101	-3.55406 39.8414	0
married*		28.20525	38.106	0.74	0.459	-46.4804 102.891	0
white*		78.44177	53.152	1.48	0.140	-25.7335 182.617	0
male*		178.6284	46.694	3.83	0.000	87.1108 270.146	0

(*) dy/dx is for discrete change of dummy variable from 0 to 1

```
. mfx, predict(e(0,.)) at(white = 0 male = 1 age = 35 married = 0 depends = 0 ///
>       educ = 16 exper = 10)
```

warning: no value assigned in at() for variables tenure;
 means used for tenure

Marginal effects after tobit

y = E(pension|pension>0) (predict, e(0,.))
 = 897.09282

variable	dy/dx	Std. Err.	z	P> z	[95% C.I.]	X
exper	3.363472	3.77305	0.89	0.373	-4.03157 10.7585	10
age	-2.998575	3.60197	-0.83	0.405	-10.0583 4.06116	35
tenure	23.28552	3.8088	6.11	0.000	15.8204 30.7506	7.75162
educ	60.25186	10.241	5.88	0.000	40.1794 80.3244	16
depends	22.80768	13.864	1.65	0.100	-4.36577 49.9811	0
married*	35.33099	47.248	0.75	0.455	-57.274 127.936	0
white*	97.63182	66.421	1.47	0.142	-32.5517 227.815	0
male*	178.6284	46.694	3.83	0.000	87.1108 270.146	1

(*) dy/dx is for discrete change of dummy variable from 0 to 1

```
. mfx, predict(e(0,.)) at(white = 1 male = 0 age = 35 married = 0 depends = 0 ///
> educ = 16 exper = 10)
```

warning: no value assigned in at() for variables tenure;
 means used for tenure

Marginal effects after tobit

y = E(pension|pension>0) (predict, e(0,.))
 = 796.90618

variable	dy/dx	Std. Err.	z	P> z	[95% C.I.]	X
exper	2.992289	3.41108	0.88	0.380	-3.69331 9.67788	10
age	-2.66766	3.24648	-0.82	0.411	-9.03065 3.69533	35
tenure	20.71579	3.08734	6.71	0.000	14.6647 26.7669	7.75162
educ	53.60263	8.10036	6.62	0.000	37.7262 69.479	16
depends	20.29069	12.56	1.62	0.106	-4.32687 44.9082	0
married*	31.49666	42.191	0.75	0.455	-51.1964 114.19	0
white*	78.44177	53.152	1.48	0.140	-25.7335 182.617	1
male*	197.8185	48.388	4.09	0.000	102.98 292.657	0

(*) dy/dx is for discrete change of dummy variable from 0 to 1

The marginal effect is calculated first for a nonwhite female. One could just sum up the marginal effect of being white and that of being male at this point, and one would obtain approximately 257. However, this would ignore the cross-derivative effect, and so a better estimate would be obtained by changing either one of `male` or `white` and then calculating the marginal effect at this point. There are two paths that lead from nonwhite female to white male. The first estimate (first the effect from female to male and then nonwhite to white) yields $178.63 + 97.63 =$

276.26, whereas the second estimate (first the effect from nonwhite to white and then from female to male) yields $78.44 + 197.82 = 276.26$.

If one interprets the question as asking for the the unconditional expectation of the difference in pensions, then the answer one obtains can be different.

d)

```
. tobit pension exper age tenure educ depends married white male union, ll(0)
```

```
Tobit regression                               Number of obs =      616
                                                LR chi2(9)       =    233.52
                                                Prob > chi2      =    0.0000
Log likelihood = -3648.5515                    Pseudo R2       =    0.0310
```

pension	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
exper	4.393523	5.830946	0.75	0.451	-7.057754	15.8448
age	-1.653532	5.555708	-0.30	0.766	-12.56427	9.257211
tenure	28.77837	4.504963	6.39	0.000	19.93116	37.62557
educ	106.8277	10.77274	9.92	0.000	85.67134	127.9841
depends	41.46623	21.21414	1.95	0.051	-.1957922	83.12824
married	19.74554	69.50047	0.28	0.776	-116.745	156.2361
white	159.2972	98.96747	1.61	0.108	-35.06298	353.6575
male	257.2457	68.02051	3.78	0.000	123.6615	390.8298
union	439.046	62.48832	7.03	0.000	316.3265	561.7656
_cons	-1571.506	218.5445	-7.19	0.000	-2000.701	-1142.311
/sigma	652.8974	23.16287			607.4083	698.3865

```
Obs. summary:      172 left-censored observations at pension<=0
                   444 uncensored observations
                   0 right-censored observations
```

Union membership increases the pension significantly, both statistically and economically. The effect of being white is still not statistically significantly different from 0.

5) a)

```
. use ~/Documents/Economics/data/mroz.dta
```

```
. reg lwage educ exper expersq if inlf == 1
```

Source	SS	df	MS	Number of obs =	428
				F(3, 424) =	26.29

Model		35.0223023	3	11.6741008	Prob > F	=	0.0000
Residual		188.305149	424	.444115917	R-squared	=	0.1568

Total		223.327451	427	.523015108	Adj R-squared	=	0.1509
					Root MSE	=	.66642

lwage		Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
educ		.1074896	.0141465	7.60	0.000	.0796837	.1352956
exper		.0415665	.0131752	3.15	0.002	.0156697	.0674633
expersq		-.0008112	.0003932	-2.06	0.040	-.0015841	-.0000382
_cons		-.5220407	.1986321	-2.63	0.009	-.9124668	-.1316145

The return to education is statistically significantly different from 0, estimated at 0.107

b)

```
. heckman lwage educ exper expersq, twostep select(nwifeinc age kidslt6 ///
> kidsge6 educ exper expersq)
```

```
Heckman selection model -- two-step estimates      Number of obs      =      753
(regression model with sample selection)          Censored obs       =      325
                                                    Uncensored obs     =      428

                                                    Wald chi2(6)       =      180.10
                                                    Prob > chi2        =      0.0000
```

		Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
lwage							
educ		.1090655	.015523	7.03	0.000	.0786411	.13949
exper		.0438873	.0162611	2.70	0.007	.0120163	.0757584
expersq		-.0008591	.0004389	-1.96	0.050	-.0017194	1.15e-06
_cons		-.5781033	.3050062	-1.90	0.058	-1.175904	.0196979
select							
nwifeinc		-.0120237	.0048398	-2.48	0.013	-.0215096	-.0025378
age		-.0528527	.0084772	-6.23	0.000	-.0694678	-.0362376
kidslt6		-.8683285	.1185223	-7.33	0.000	-1.100628	-.636029
kidsge6		.036005	.0434768	0.83	0.408	-.049208	.1212179
educ		.1309047	.0252542	5.18	0.000	.0814074	.180402
exper		.1233476	.0187164	6.59	0.000	.0866641	.1600311
expersq		-.0018871	.0006	-3.15	0.002	-.003063	-.0007111
_cons		.2700768	.508593	0.53	0.595	-.7267472	1.266901

```

-----+-----
mills |
      lambda |   .0322619   .1336246   0.24   0.809   -.2296376   .2941613
-----+-----
      rho |     0.04861
      sigma |   .66362876
      lambda |   .03226186   .1336246
-----+-----

```

The estimate for the return to education is quite close to that found by the OLS regression. The coefficient on the inverse Mills ratio, denote λ is not statistically significantly different from 0, indicating that selection bias is not a problem.

c)

```

. heckman lwage educ exper expersq, select(nwifeinc age kidslt6 kidsge6 ///
>      educ exper expersq)

```

```

Iteration 0:  log likelihood = -832.89777
Iteration 1:  log likelihood = -832.8851
Iteration 2:  log likelihood = -832.88509

```

```

Heckman selection model          Number of obs    =      753
(regression model with sample selection)  Censored obs    =      325
                                           Uncensored obs  =      428

                                           Wald chi2(3)    =      59.67
Log likelihood = -832.8851         Prob > chi2     =      0.0000

```

```

-----+-----
          |      Coef.   Std. Err.   z   P>|z|   [95% Conf. Interval]
-----+-----
lwage    |
  educ   |   .1083502   .0148607   7.29  0.000   .0792238   .1374767
  exper  |   .0428369   .0148785   2.88  0.004   .0136755   .0719983
  expersq |  -.0008374   .0004175  -2.01  0.045  -.0016556  -.0000192
  _cons  |  -.5526974   .2603784  -2.12  0.034  -1.06303  -.0423652
-----+-----
select   |
  nwifeinc |  -.0121321   .0048767  -2.49  0.013  -.0216903  -.002574
    age    |  -.0528287   .0084792  -6.23  0.000  -.0694476  -.0362098
  kidslt6 |  -.8673988   .1186509  -7.31  0.000  -1.09995  -.6348472
  kidsge6 |   .0358723   .0434753   0.83  0.409  -.0493377   .1210824
    educ   |   .1313415   .0253823   5.17  0.000   .0815931   .1810899
    exper  |   .1232818   .0187242   6.58  0.000   .0865831   .1599806
  expersq |  -.0018863   .0006004  -3.14  0.002  -.003063  -.0007095

```

_cons		.2664491	.5089578	0.52	0.601	-.7310898	1.263988

/athrho		.026614	.147182	0.18	0.857	-.2618573	.3150854
/lnsigma		-.4103809	.0342291	-11.99	0.000	-.4774687	-.3432931

rho		.0266078	.1470778			-.2560319	.3050564
sigma		.6633975	.0227075			.6203517	.7094303
lambda		.0176515	.0976057			-.1736521	.2089552

LR test of indep. eqns. (rho = 0):				chi2(1) =	0.03	Prob > chi2 =	0.8577

The estimate for return to education is pretty much the same, and the likelihood ratio test fails to reject the null hypothesis that ρ is statistically significantly different from 0, which implies that ignoring selection is acceptable.