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Homework 7

a) Estimate the two-equation SUR system for hourly wage and hourly benefits using FGLS to achieve results identical to those in Table 7.1 in the text.

The results from Table 7.1 in the text is shown below:

Table 7.1
An Estimated SUR Model for Hourly Wages and Hourly Benefits

Explanatory Variables	*hrearn*	*hrbens*
educ	.459 (.069)	.077 (.008)
exper	−.076 (.057)	.023 (.007)
$exper^2$	.0040 (.0012)	−.0005 (.0001)
tenure	.110 (.084)	.054 (.010)
$tenure^2$	−.0051 (.0033)	−.0012 (.0004)
union	.808 (.408)	.366 (.049)
south	−.457 (.552)	−.023 (.066)
nrtheast	−1.151 (0.606)	−.057 (.072)
nrthcen	−.636 (.556)	−.038 (.066)
married	.642 (.418)	.058 (.050)
white	1.141 (0.612)	.090 (.073)
male	1.785 (0.398)	.268 (.048)
intercept	−2.632 (1.228)	−.890 (.147)

The results from FGLS in R is shown below:

```
systemfit results
method: SUR

SUR estimates for 'earnings' (equation 1)
Model Formula: hrearn ~ educ + exper + expersq + tenure + tenuresq +
 union +
    south + nrtheast + nrthcen + married + white + male

               Estimate  Std. Error  t value   Pr(>|t|)
(Intercept) -2.63212671  1.22832151 -2.14286  0.0325236 *
educ         0.45881395  0.06912628  6.63733 7.1256e-11 ***
exper       -0.07584282  0.05734542 -1.32256  0.1864828
expersq      0.00399449  0.00117795  3.39104  0.0007418 ***
tenure       0.11008462  0.08380979  1.31351  0.1895122
tenuresq    -0.00507064  0.00327692 -1.54738  0.1222965
union        0.80799328  0.40780495  1.98132  0.0480089 *
south       -0.45662223  0.55170344 -0.82766  0.4081912
nrtheast    -1.15075861  0.60575425 -1.89971  0.0579478 .
nrthcen     -0.63626628  0.55604484 -1.14427  0.2529651
married      0.64238821  0.41779850  1.53756  0.1246820
white        1.14089121  0.61193899  1.86439  0.0627530 .
male         1.78470236  0.39800745  4.48409 8.7674e-06 ***
---
SUR estimates for 'benefits' (equation 2)
```

```
Model Formula: hrbens ~ educ + exper + expersq + tenure + tenuresq +
 union +
    south + nrtheast + nrthcen + married + white + male

                Estimate   Std. Error  t value   Pr(>|t|)
(Intercept) -0.889747099  0.146883282 -6.05751 2.4342e-09 ***
educ         0.076792360  0.008266154  9.28997 < 2.22e-16 ***
exper        0.022564931  0.006857393  3.29060  0.0010581 **
expersq     -0.000473359  0.000140860 -3.36049  0.0008272 ***
tenure       0.053555571  0.010022015  5.34379 1.2924e-07 ***
tenuresq    -0.001163631  0.000391856 -2.96954  0.0031010 **
union        0.365908540  0.048765513  7.50343 2.2404e-13 ***
south       -0.022686547  0.065972964 -0.34388  0.7310591
nrtheast    -0.056746823  0.072436387 -0.78340  0.4336986
nrthcen     -0.037998394  0.066492111 -0.57147  0.5678925
married      0.057862604  0.049960547  1.15817  0.2472548
white        0.090158182  0.073175962  1.23207  0.2184017
male         0.268338264  0.047593923  5.63808 2.6438e-08 ***
---
```

The above results show that they produce identical outcomes.

b) Estimate the same two-equation SUR system using SOLS.

```
systemfit results
method: OLS


OLS estimates for 'earnings' (equation 1)
Model Formula: hrearn ~ educ + exper + expersq + tenure + tenuresq +
 union +
    south + nrtheast + nrthcen + married + white + male

               Estimate  Std. Error  t value   Pr(>|t|)
(Intercept) -2.63212671  1.22832151 -2.14286  0.0325236 *
educ         0.45881395  0.06912628  6.63733 7.1256e-11 ***
exper       -0.07584282  0.05734542 -1.32256  0.1864828
expersq      0.00399449  0.00117795  3.39104  0.0007418 ***
tenure       0.11008462  0.08380979  1.31351  0.1895122
tenuresq    -0.00507064  0.00327692 -1.54738  0.1222965
union        0.80799328  0.40780495  1.98132  0.0480089 *
south       -0.45662223  0.55170344 -0.82766  0.4081912
nrtheast    -1.15075861  0.60575425 -1.89971  0.0579478 .
nrthcen     -0.63626628  0.55604484 -1.14427  0.2529651
married      0.64238821  0.41779850  1.53756  0.1246820
white        1.14089121  0.61193899  1.86439  0.0627530 .
male         1.78470236  0.39800745  4.48409 8.7674e-06 ***
---

OLS estimates for 'benefits' (equation 2)
Model Formula: hrbens ~ educ + exper + expersq + tenure + tenuresq +
 union +
    south + nrtheast + nrthcen + married + white + male

                Estimate   Std. Error  t value   Pr(>|t|)
(Intercept) -0.889747099  0.146883282 -6.05751 2.4342e-09 ***
educ         0.076792360  0.008266154  9.28997 < 2.22e-16 ***
exper        0.022564931  0.006857393  3.29060  0.0010581 **
expersq     -0.000473359  0.000140860 -3.36049  0.0008272 ***
tenure       0.053555571  0.010022015  5.34379 1.2924e-07 ***
tenuresq    -0.001163631  0.000391856 -2.96954  0.0031010 **
```

```
union        0.365908540  0.048765513  7.50343 2.2404e-13 ***
south       -0.022686547  0.065972964 -0.34388  0.7310591
nrtheast    -0.056746823  0.072436387 -0.78340  0.4336986
nrthcen     -0.037998394  0.066492111 -0.57147  0.5678925
married      0.057862604  0.049960547  1.15817  0.2472548
white        0.090158182  0.073175962  1.23207  0.2184017
male         0.268338264  0.047593923  5.63808 2.6438e-08 ***
---
```

c) Comment on the relationship between the above two sets of results.

The above two sets of results is an example where SOLS and FGLS are identical. There are two situations where SOLS and FGLS are identical. 1) if omega-hat is a diagonal matrix; 2) if, for every observation, the same regressors show up in every equation. The two sets of results above satisfy these two conditions.

d) Disaggregate the hourly benefits variable into its four components:
   - Value of vacation days
   - Value of sick leave
   - Value of employer-provided insurance
   - Value of pension

   Estimate a SUR model of this five-equation system.

```
systemfit results
method: SUR

SUR estimates for 'vacation' (equation 1)
Model Formula: hrvacdays ~ educ + exper + expersq + tenure + tenures
q + union +
    south + nrtheast + nrthcen + married + white + male

                Estimate   Std. Error  t value   Pr(>|t|)
(Intercept) -1.84235e-01  3.96213e-02 -4.64989 4.0834e-06 ***
educ         2.01829e-02  2.22977e-03  9.05156 < 2.22e-16 ***
exper        6.64930e-03  1.84976e-03  3.59468 0.00035135 ***
expersq     -1.49186e-04  3.79966e-05 -3.92631 9.6216e-05 ***
tenure       1.23860e-02  2.70341e-03  4.58162 5.6093e-06 ***
tenuresq    -2.15548e-04  1.05702e-04 -2.03921 0.04186485 *
union        6.37464e-02  1.31544e-02  4.84603 1.6039e-06 ***
south       -1.79005e-02  1.77960e-02 -1.00587 0.31488065
nrtheast    -1.69824e-02  1.95395e-02 -0.86913 0.38512192
nrthcen      2.51051e-04  1.79361e-02  0.01400 0.98883702
married      2.27586e-02  1.34767e-02  1.68874 0.09178702 .
white        8.48687e-03  1.97390e-02  0.42995 0.66738237
male         5.69525e-02  1.28383e-02  4.43614 1.0888e-05 ***
---

SUR estimates for 'sickleave' (equation 2)
Model Formula: hrsicklve ~ educ + exper + expersq + tenure + tenures
q + union +
    south + nrtheast + nrthcen + married + white + male

                Estimate   Std. Error  t value   Pr(>|t|)
(Intercept) -9.37606e-02  1.62271e-02 -5.77803 1.2121e-08 ***
educ         9.60544e-03  9.13213e-04 10.51829 < 2.22e-16 ***
exper        2.14499e-03  7.57578e-04  2.83138  0.0047894 **
expersq     -3.82570e-05  1.55617e-05 -2.45841  0.0142354 *
tenure       5.00207e-03  1.10719e-03  4.51780 7.5205e-06 ***
tenuresq    -1.39104e-04  4.32907e-05 -3.21325  0.0013824 **
```

```
union       -4.66553e-03  5.38742e-03 -0.86600  0.3868323
south       -1.19420e-02  7.28844e-03 -1.63848  0.1018432
nrtheast    -2.66511e-03  8.00249e-03 -0.33303  0.7392236
nrthcen     -2.22014e-02  7.34579e-03 -3.02233  0.0026148 **
married      3.83380e-03  5.51945e-03  0.69460  0.4875745
white        3.86350e-03  8.08420e-03  0.47791  0.6328891
male         4.25383e-03  5.25799e-03  0.80902  0.4188218
---

SUR estimates for 'insurance' (equation 3)
Model Formula: hrinsur ~ educ + exper + expersq + tenure + tenuresq
+ union +
    south + nrtheast + nrthcen + married + white + male

               Estimate   Std. Error  t value   Pr(>|t|)
(Intercept) -1.18082e-01  4.48636e-02 -2.63203 0.00870496 **
educ         8.00420e-03  2.52479e-03  3.17024 0.00160035 **
exper        5.40522e-03  2.09450e-03  2.58067 0.01009616 *
expersq     -1.26561e-04  4.30239e-05 -2.94164 0.00339007 **
tenure       1.16978e-02  3.06110e-03  3.82145 0.00014643 ***
tenuresq    -2.46647e-04  1.19688e-04 -2.06076 0.03975416 *
union        1.44154e-01  1.48948e-02  9.67811 < 2.22e-16 ***
south        1.96786e-02  2.01506e-02  0.97657 0.32917143
nrtheast    -5.25635e-03  2.21248e-02 -0.23758 0.81228950
nrthcen      2.42515e-02  2.03092e-02  1.19411 0.23290279
married      3.65441e-02  1.52598e-02  2.39479 0.01693391 *
white        3.78883e-02  2.23507e-02  1.69518 0.09055839 .
male         1.12006e-01  1.45370e-02  7.70490 5.4179e-14 ***
---

SUR estimates for 'pension' (equation 4)
Model Formula: hrpension ~ educ + exper + expersq + tenure + tenures
q + union +
    south + nrtheast + nrthcen + married + white + male

               Estimate   Std. Error  t value   Pr(>|t|)
(Intercept) -4.92834e-01  7.12776e-02 -6.91429 1.2014e-11 ***
educ         3.90226e-02  4.01129e-03  9.72819 < 2.22e-16 ***
exper        8.37915e-03  3.32767e-03  2.51803  0.0120593 *
expersq     -1.59506e-04  6.83548e-05 -2.33350  0.0199494 *
tenure       2.43758e-02  4.86335e-03  5.01214 7.0843e-07 ***
tenuresq    -5.59692e-04  1.90155e-04 -2.94335  0.0033717 **
union        1.62140e-01  2.36643e-02  6.85169 1.8059e-11 ***
south       -1.30816e-02  3.20145e-02 -0.40862  0.6829670
nrtheast    -3.23117e-02  3.51510e-02 -0.91923  0.3583446
nrthcen     -4.08177e-02  3.22664e-02 -1.26502  0.2063528
married     -5.17554e-03  2.42442e-02 -0.21348  0.8310283
white        3.95839e-02  3.55099e-02  1.11473  0.2654100
male         9.52459e-02  2.30958e-02  4.12395 4.2469e-05 ***
---

SUR estimates for 'earnings' (equation 5)
Model Formula: hrearn ~ educ + exper + expersq + tenure + tenuresq +
 union +
    south + nrtheast + nrthcen + married + white + male

              Estimate  Std. Error  t value   Pr(>|t|)
(Intercept) -2.63212671  1.22832151 -2.14286  0.0325236 *
educ         0.45881395  0.06912628  6.63733 7.1256e-11 ***
exper       -0.07584282  0.05734542 -1.32256  0.1864828
expersq      0.00399449  0.00117795  3.39104  0.0007418 ***
tenure       0.11008462  0.08380979  1.31351  0.1895122
tenuresq    -0.00507064  0.00327692 -1.54738  0.1222965
```

```
union        0.80799328  0.40780495  1.98132  0.0480089 *
south       -0.45662223  0.55170344 -0.82766  0.4081912
nrtheast    -1.15075861  0.60575425 -1.89971  0.0579478 .
nrthcen     -0.63626628  0.55604484 -1.14427  0.2529651
married      0.64238821  0.41779850  1.53756  0.1246820
white        1.14089121  0.61193899  1.86439  0.0627530 .
male         1.78470236  0.39800745  4.48409 8.7674e-06 ***
---
```

e) Test whether marital status has an effect on any of the five forms of compensation.

```
Linear hypothesis test (F statistic of a Wald test)

Hypothesis:
vacation_married = 0
sickleave_married = 0
insurance_married = 0
pension_married = 0
earnings_married = 0

Model 1: restricted model
Model 2: res.FGLS

  Res.Df Df      F  Pr(>F)
1   3020
2   3015  5 2.8354 0.01468 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

The F test shows that marital status has effect on at least on of the five forms of compensation. According to the result from part e, marital status only has effect on hrinsur (.037 with t=2. 42). It is also almost significant for the effect on hrvacdays.

f) Test whether another year of education increases expected pension value and expected insurance by the same amount.

```
Linear hypothesis test (F statistic of a Wald test)

Hypothesis:
pension_educ - earnings_educ = 0

Model 1: restricted model
Model 2: res.FGLS

  Res.Df Df      F    Pr(>F)
1   3016
2   3015  1 37.979 8.101e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

The linear hypothesis command tests whether another year of education has the same effect on hrpension and hrinsur. The f statistic is 37.979 > 10 and the p-value is close to zero. The estimate in the hrpension equation (with standard error) is .039 (. 004) while the estimate in the hrinsur equation is .008 (. 003). Thus, each is positive and statistically significant, and they are significantly different from one another.