An Analysis of the Effect of Unemployment and Scholarships on Male and Female Enrollment

By Collin DeVore

Introduction

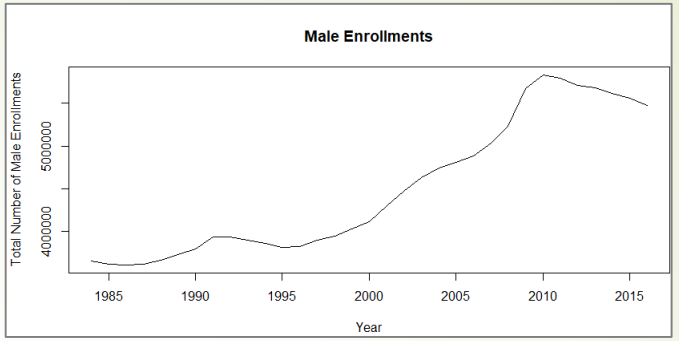
- Julian R. Betts and Laurel L. McFarland (1995) – Analyzes the effect of unemployment on community college enrollment rates. Finds that, not only do community college enrollments experience a positive effect from increased unemployment rates, but that colleges lose revenue as unemployment rates go up because the federal government begins cutting funding.
- Nicholas W. Hillman and Erica Lee Orians (2013) – Updates the work of Betts and McFarland while simultaneously including data from the Great Recession and controlling for other factors such as tuition.
- James Wetzel, Dennis O'Toole, and Steven Peterson (1998) – Analyzes the effect of the cost of college on minority students. Finds that minority students react more strongly to changes in the cost of college. Suggests that these same students would react more to changes in financial aid as well. Also finds that the aggregated cost does not have much effect on the number of enrollments.
- Andrew Braunstein, Michael McGrath, and Donn Pescatrice (1999) – Studies the effect of the elasticities of scholarships on the elasticities of college enrollment. Finds that, while scholarships heavily influence the amount of enrollments that take place, the scholarships and the enrollments also depend on the labor market and the college itself.
- Ayako Kondo – Studies the impact of entering the labor force during a recession on men and women, and between race. Finds that males are more affected by the recession than the females, and that the effect stays the same between races.
- It appears as though no one has begun studying the impact of the different predictor variables on males and females using cointegration and seemingly unrelated regression (SUR)

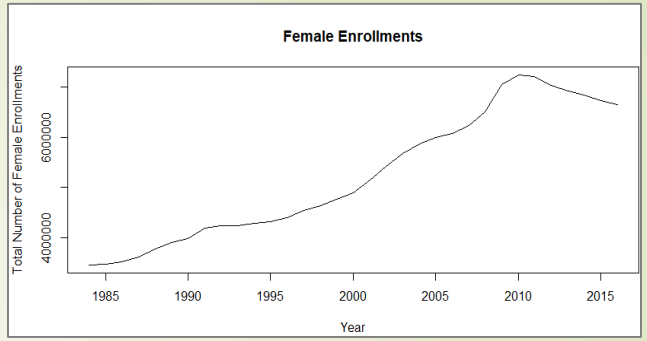
Data

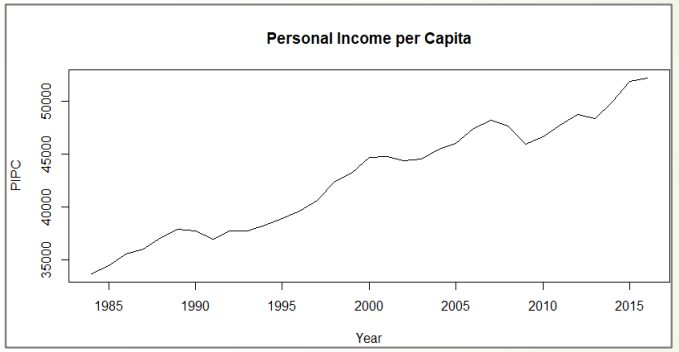
- Analyzed the male and female fall enrollment rates from 1984 to 2016
  - 33 year period
  - Annual data
  - Since the 2004 issue was not released to the public, 2002 was never reported, so the data from 2001 and 2003 is averaged as a proxy
- Data comes from the:
  - Digest of Education Statistics (years 1987 – 2017): Male and Female Full Time Bachelor's Enrollment Data
  - Federal Reserve of Saint Louis (FRED): Personal Income per Capita
    - Proxy for income
    - Adjusted to 2018 dollars using the consumer price index provided by US Inflation Calculator
  - Federal Reserve of Saint Louis (FRED): Unemployment Rate
    - Monthly unemployment rate averaged to become annual unemployment rate
  - Collegeboard: Tuition and other such fees over time
    - Already adjusted to 2018 dollars
    - Proxy for costs
  - Collegeboard: Average scholarships and other aid per student each year
    - Adjusted from 2017 dollars to 2018 dollars using the consumer price index provided by US Inflation Calculator

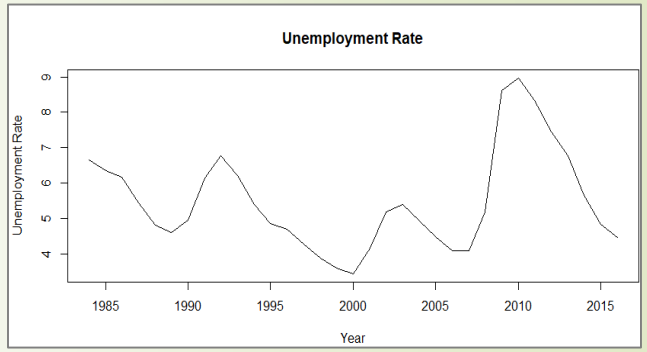
Methods

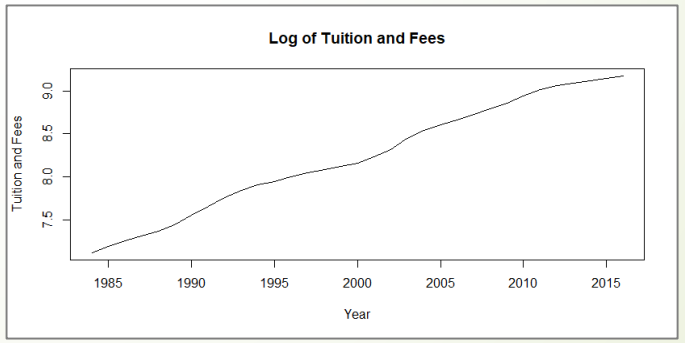
- Variables chosen:
  - Personal Income per Capita
  - Unemployment Rate
  - Tuition and Fees
  - Average Scholarships per Student
- Here, we begin by looking at the graphs of the functions
- It looks as though some of the data is reacting to changes in other variables
- Male and female enrollments look as though they may cointegrate with the average amount of scholarships given per student

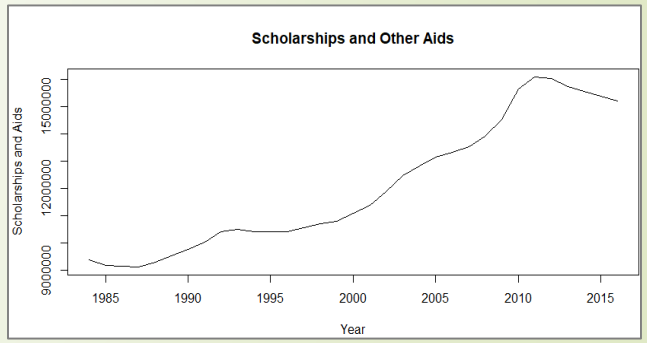












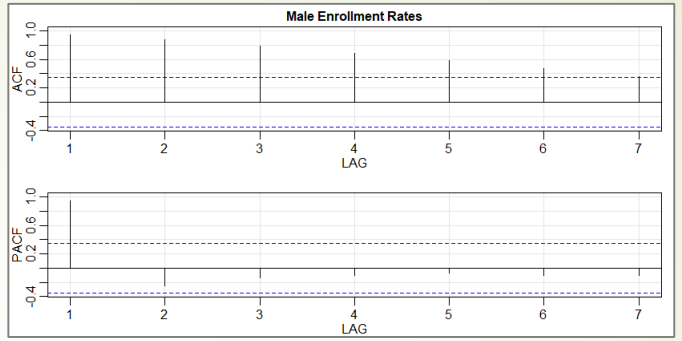
Dickey – Fuller Tests

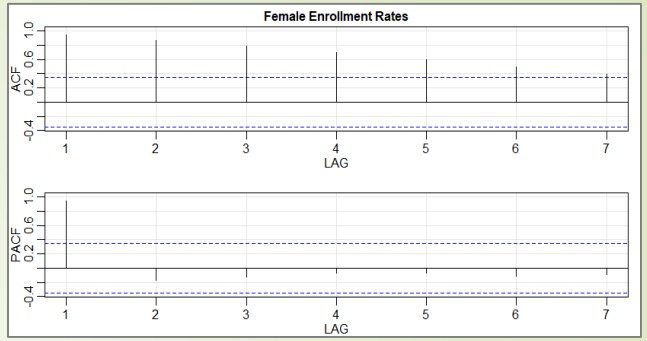
Dickey – Fuller Test								
	Overall Value of the Test Statistic			5 pct Critical Value			Significance Level	Reject/Fail to Reject
	Tau	Phi1	Phi2	Tau	Phi1	Phi2	P – Value	Null
Male Enrollments (No trend or drift)	2.852	N/A	N/A	-1.95	N/A	N/A	0.007666	Reject
Male Enrollments (with drift)	-0.1226	4.1779	N/A	-2.93	4.86	N/A	0.9032	Fail to Reject
Male Enrollments (with trend)	-1.4709	3.6723	1.1574	-3.50	5.13	6.73	0.3284	Fail to Reject
Female Enrollments (No trend or drift)	3.545	N/A	N/A	-1.95	N/A	N/A	0.00127	Reject
Female Enrollments (with drift)	-0.9144	8.4377	N/A	-2.93	4.86	N/A	0.3678	Fail to Reject
Female Enrollments (with trend)	-0.4781	5.4805	0.4464	-3.50	5.13	6.73	0.6442	Fail to Reject
Personal Income per Cap (No trend or drift)	4.0722	N/A	N/A	-1.95	N/A	N/A	0.0002988	Reject
Personal Income per Cap (with drift)	-0.3189	8.5183	N/A	-2.93	4.86	N/A	0.752	Fail to Reject
Personal Income per Cap (with trend)	-2.1863	7.9333	2.3949	-3.50	5.13	6.73	0.109	Fail to Reject
Unemployment (No trend or drift)	-0.8669	N/A	N/A	-1.95	N/A	N/A	0.3927	Fail to Reject
Unemployment (with drift)	-1.7945	1.7167	N/A	-2.93	4.86	N/A	0.08281	Fail to Reject
Unemployment (with trend)	-1.8099	1.1622	1.6398	-3.50	5.13	6.73	0.2115	Fail to Reject
Log of Tuition and Fees (No trend or drift)	12.8377	N/A	N/A	-1.95	N/A	N/A	0.00000000	Reject
Log of Tuition and Fees (with drift)	-2.1056	112.8256	N/A	-2.93	4.86	N/A	0.04372	Reject
Log of Tuition and Fees (with trend)	-0.1637	72.7102	2.1429	-3.50	5.13	6.73	0.1355	Fail to Reject
Scholarships and Aid (No trend or drift)	3.4407	N/A	N/A	-1.95	N/A	N/A	0.001679	Reject
Scholarships and Aid (with drift)	0.0469	5.9903	N/A	-2.93	4.86	N/A	0.9629	Fail to Reject
Scholarships and Aid (with trend)	-1.7818	5.4844	1.742	-3.50	5.13	6.73	0.193	Fail to Reject
Differenced Log Tuition and Fees (No trend or drift)	-1.023	N/A	N/A	-1.95	N/A	N/A	0.3142	Fail to Reject
Differenced Log Tuition and Fees (with drift)	-1.9313	1.9469	N/A	-2.93	4.86	N/A	0.06294	Fail to Reject
Differenced Tuition and Fees (with trend)	-2.2275	1.8444	2.683	-3.50	5.13	6.73	0.08529	Fail to Reject

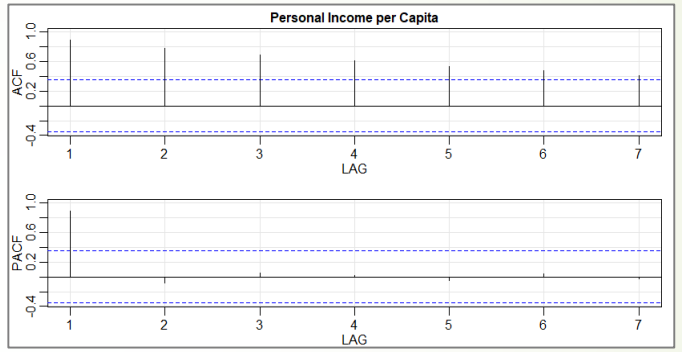
- Next we look at stationarity

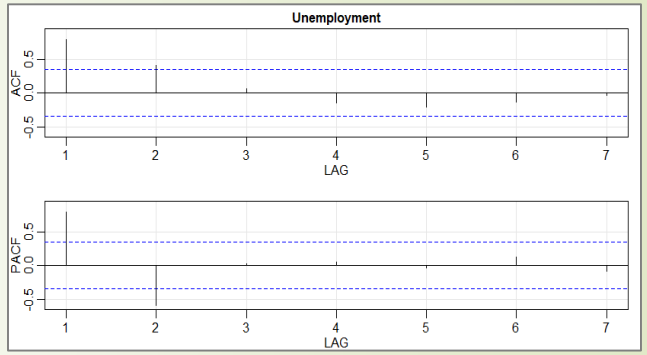
Autocorrelation and Partial Autocorrelation Functions

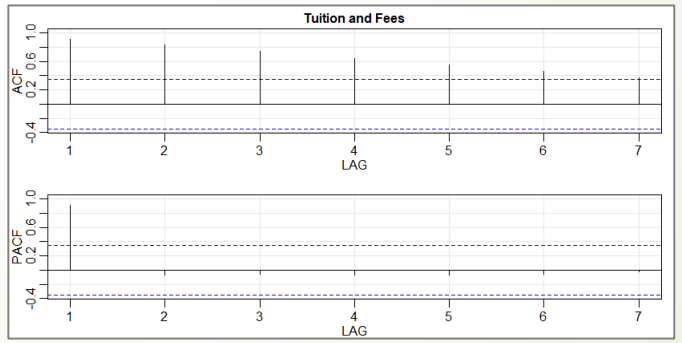
- The autocorrelation and partial autocorrelation functions appear to show strong persistence among many of the variables, besides unemployment
  - Unemployment was shown to be nonstationary by the Dickey – Fuller test nonetheless
- For this reason, we can first – difference each of the variables
  - Tuition and Fees will need to be differenced twice, as shown by the Dickey – Fuller tests

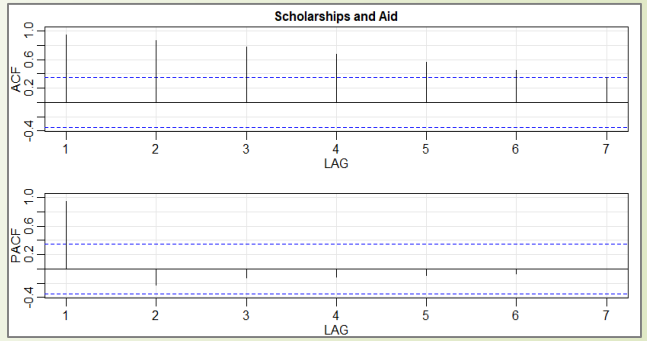






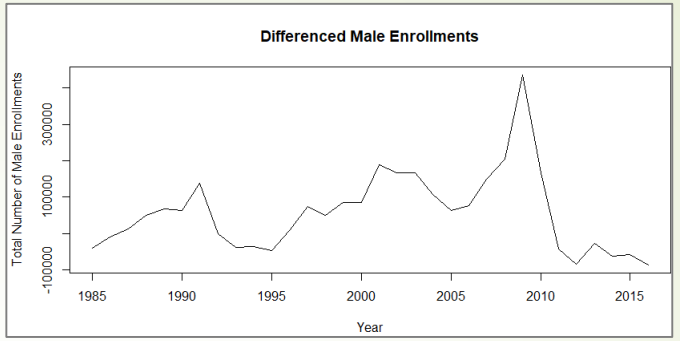


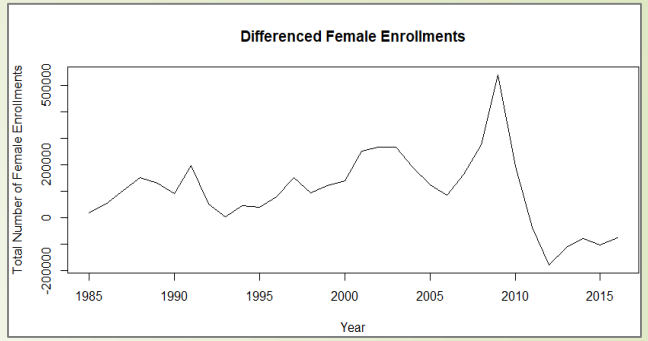


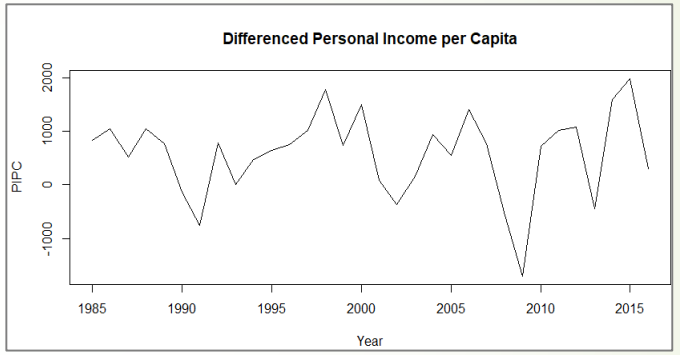


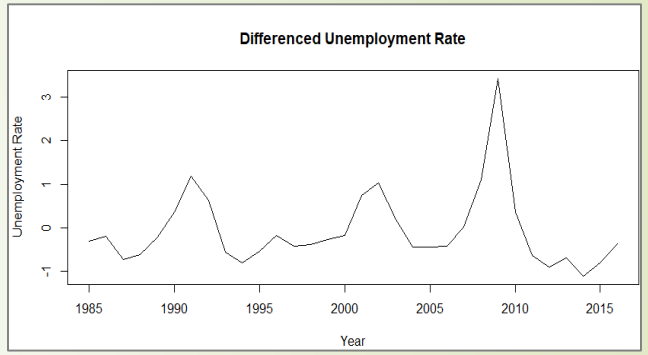
Differenced Graphs

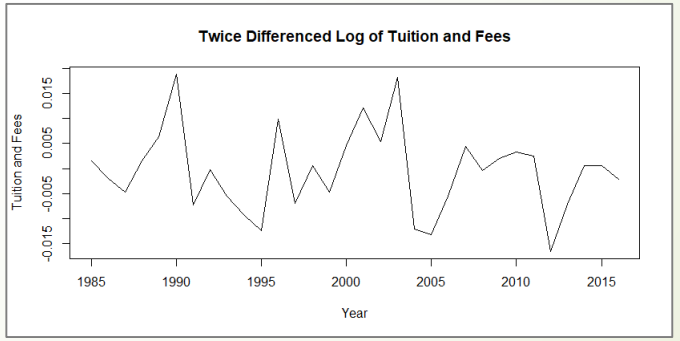
- It now looks as though male enrollments, female enrollments, the unemployment rate, and the scholarships and other aids are following the same paths over time
- It is not completely clear from this graph if personal income per capita and the log of tuition are following the same path, though they could be somehow inversely related

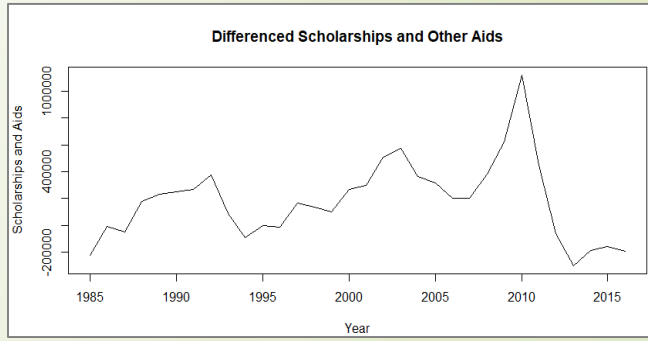












Engle – Granger Two – Step Cointegration Test

- It looks as though scholarships and males are cointegrated
- It is possible that females and scholarships are cointegrated, but we can not be 95% sure of this
- For this reason, we ignore cointegration effects for the SUR and only focus on the short run effects

Step One: Regression Equations

$$Male = -1{,}288{,}470.0 + 135.1 * pipc + \varepsilon_t$$
$$Female = -4{,}418{,}902.9 + 225.6 * pipc + \varepsilon_t$$
$$Male = 3{,}219{,}389 + 232{,}396 * unemp + \varepsilon_t$$
$$Female = 3{,}701{,}397 + 280{,}243 * unemp + \varepsilon_t$$
$$Male = -5{,}073{,}892 + 1{,}162{,}836 * \log(tuitfee) + \varepsilon_t$$
$$Female = -10{,}598{,}058 + 1{,}924{,}747 * \log(tuitfee) + \varepsilon_t$$
$$Male = 494{,}006.2621 + 0.3318 * scholarships + \varepsilon_t$$
$$Female = -1{,}122{,}687.9384 + 0.5277 * scholarships + \varepsilon_t$$

Step Two: Dickey – Fuller Test Results

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	P – Value	Reject/Fail to Reject
Personal Income per Capita (Males)	-1.645	-3.58	-2.93	-2.60	0.1104	Fail to Reject
Personal Income per Capita (Females)	-1.5054	-3.58	-2.93	-2.60	0.1427	Fail to Reject
Unemployment (Males)	-0.243	-3.58	-2.93	-2.60	0.8096	Fail to Reject
Unemployment (Females)	-1.165	-3.58	-2.93	-2.60	0.2532	Fail to Reject
Tuition and Fees (Males)	-1.7581	-3.58	-2.93	-2.60	0.08893	Fail to Reject
Tuition and Fees (Females)	-1.2043	-3.58	-2.93	-2.60	0.2379	Fail to Reject
Scholarships and Aid (Males)	-2.292	-3.58	-2.93	-2.60	0.0291	Reject
Scholarships and Aid (Females)	-1.8801	-3.58	-2.93	-2.60	0.06984	Fail to Reject

Conclusion of Engle – Granger Tests

- Regression equations can now be said to have the following forms
  - $\Delta male_t = \beta_1 \Delta pipc_t + \beta_2 \Delta unemp_t + \beta_3 \Delta tuitfee_t + \beta_4 \Delta \text{scholarships}_t + \varepsilon_t$
    $\Delta \text{female}_t = \beta_1 \Delta pipc_t + \beta_2 \Delta unemp_t + \beta_3 \Delta tuitfee_t + \beta_4 \Delta \text{scholarships}_t + \varepsilon_t$
- The long run effects of the scholarships variable will be ignored, but may be recommended for future analysis

SUR Results and Output

- Both males and females have the same significant variables
  - Significant:
    - Unemployment rate
    - Scholarships
  - Not significant
    - Personal income per capita
    - Tuition and fees
- Since two of these variables are not significant in predicting the amount of male and female enrollments, they need to be taken out so they will not bias the results

```
systemfit results
method: SUR

         N DF           SSR              detRCov  OLS-R2 McElroy-R2
system 64 54 237788881575 5994356455023388672 0.76003   0.669073

    N DF          SSR        MSE    RMSE       R2   Adj R2
m1 32 27  74634475297 2764239826 52576.0 0.800880 0.771380
f1 32 27 163154406278 6042755788 77735.2 0.735177 0.695944

The covariance matrix of the residuals used for estimation
           m1         f1
m1 2764239826 3272502063
f1 3272502063 6042755788

The covariance matrix of the residuals
           m1         f1
m1 2764239826 3272502063
f1 3272502063 6042755788

The correlations of the residuals
          m1       f1
m1 1.000000 0.800709
f1 0.800709 1.000000


SUR estimates for 'm1' (equation 1)
Model Formula: maled ~ pipcd + unempd + ltuitfeedd + scholarshipsd

                    Estimate      Std. Error t value   Pr(>|t|)
(Intercept)     39821.7196779   14769.9714822 2.69613 0.01192975 *
pipcd               2.5574094      19.0280317 0.13440 0.89408142
unempd          85680.2391329   20449.1334801 4.18992 0.00026732 ***
ltuitfeedd     165418.3622748 1234992.5878451 0.13394 0.89444122
scholarshipsd       0.1194021       0.0415413 2.87430 0.00780106 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 52576.038514 on 27 degrees of freedom
Number of observations: 32 Degrees of Freedom: 27
SSR: 74634475297.1815 MSE: 2764239825.82154 Root MSE: 52576.038514
Multiple R-Squared: 0.80088 Adjusted R-Squared: 0.77138


SUR estimates for 'f1' (equation 2)
Model Formula: femaled ~ pipcd + unempd + ltuitfeedd + scholarshipsd

                    Estimate     Std. Error  t value  Pr(>|t|)
(Intercept)     78743.239247   21837.821832  3.60582 0.0012431 **
pipcd              -1.252226      28.133485 -0.04451 0.9648253
unempd          97317.151811   30234.623953  3.21873 0.0033390 **
ltuitfeedd     594151.313398 1825971.575501  0.32539 0.7473948
scholarshipsd       0.159764       0.061420  2.60117 0.0148930 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 77735.164424 on 27 degrees of freedom
Number of observations: 32 Degrees of Freedom: 27
SSR: 163154406277.992 MSE: 6042755788.07379 Root MSE: 77735.164424
Multiple R-Squared: 0.735177 Adjusted R-Squared: 0.695944
```

Adjusted SUR Results and Output

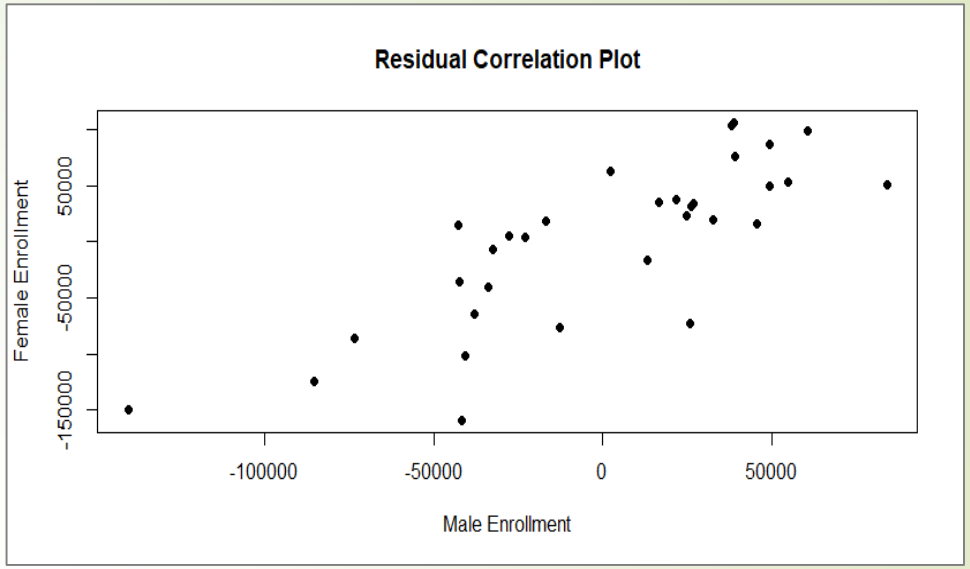
- Now, the setup of the SUR model is complete
- The simplified equations are given above
- Male enrollments and female enrollments now only consist of significant predictor variables
- Males and Females now have the same equations
- Next, we must analyze the residuals and address concerns

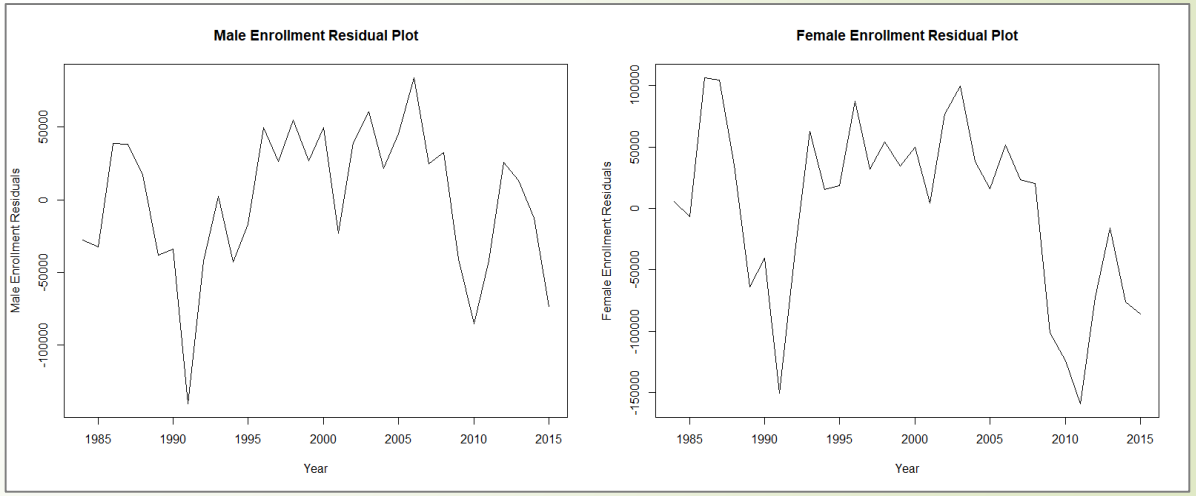
$$\Delta males_t = 40{,}638.5355159 + (83{,}997.7942077 * \Delta unemployment_t) + (0.1218895 * \Delta scholarships_t) + \varepsilon_t$$
$$\Delta females_t = 77{,}324.2724275 + (99{,}475.1343452 * \Delta unemployment_t) + (0.1625278 * \Delta scholarships_t) + \varepsilon_t$$

```
systemfit results
method: SUR

         N DF           SSR             detRCov   OLS-R2 McElroy-R2
system 64 58 238547418880 5237448021568674816 0.759264   0.668267

    N DF          SSR        MSE    RMSE       R2   Adj R2
m3 32 29  74752880129 2577685522 50770.9 0.800564 0.786810
f3 32 29 163794538751 5648087543 75153.8 0.734138 0.715803

The covariance matrix of the residuals used for estimation
           m3         f3
m3 2577685522 3053120611
f3 3053120611 5648087543

The covariance matrix of the residuals
           m3         f3
m3 2577685522 3053120611
f3 3053120611 5648087543

The correlations of the residuals
          m3       f3
m3 1.000000 0.800163
f3 0.800163 1.000000


SUR estimates for 'm3' (equation 1)
Model Formula: maled ~ unempd + scholarshipsd

                   Estimate    Std. Error t value      Pr(>|t|)
(Intercept)   40638.5355159 11707.9258260 3.47103     0.0016449 **
unempd        83997.7942077 12849.8506036 6.53687 0.00000036937 ***
scholarshipsd     0.1218895     0.0382899 3.18333     0.0034626 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 50770.912161 on 29 degrees of freedom
Number of observations: 32 Degrees of Freedom: 29
SSR: 74752880129.4501 MSE: 2577685521.70518 Root MSE: 50770.912161
Multiple R-Squared: 0.800564 Adjusted R-Squared: 0.78681


SUR estimates for 'f3' (equation 2)
Model Formula: femaled ~ unempd + scholarshipsd

                   Estimate    Std. Error t value    Pr(>|t|)
(Intercept)   77324.2724275 17330.6840955 4.46170  0.00011287 ***
unempd        99475.1343452 19021.0208705 5.22975 0.000013394 ***
scholarshipsd     0.1625278     0.0566787 2.86753  0.00763154 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 75153.759341 on 29 degrees of freedom
Number of observations: 32 Degrees of Freedom: 29
SSR: 163794538751.039 MSE: 5648087543.13928 Root MSE: 75153.759341
Multiple R-Squared: 0.734138 Adjusted R-Squared: 0.715803
```

Residual Diagnostics and Concerns

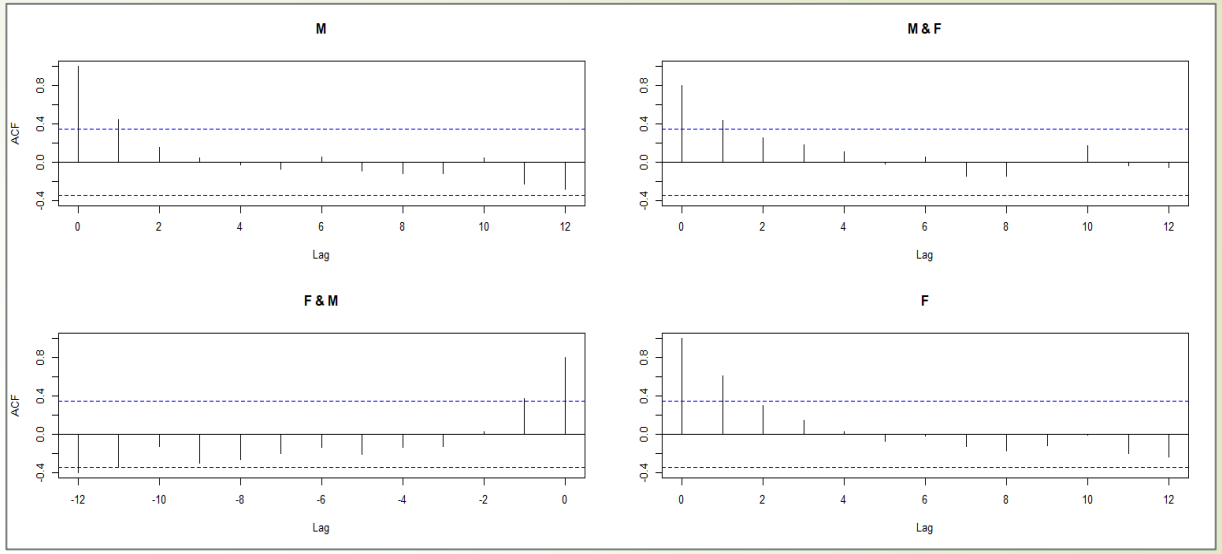
- Now that the model has been established, the residuals can be analyzed
- The Dickey – Fuller tests give the following results:
  - Male p – value: 0.02002
    - Stationary
  - Female p – value: 0.0737
    - Non – Stationary?
- The residuals appear to follow the same basic path here
- One other concern must be addressed…

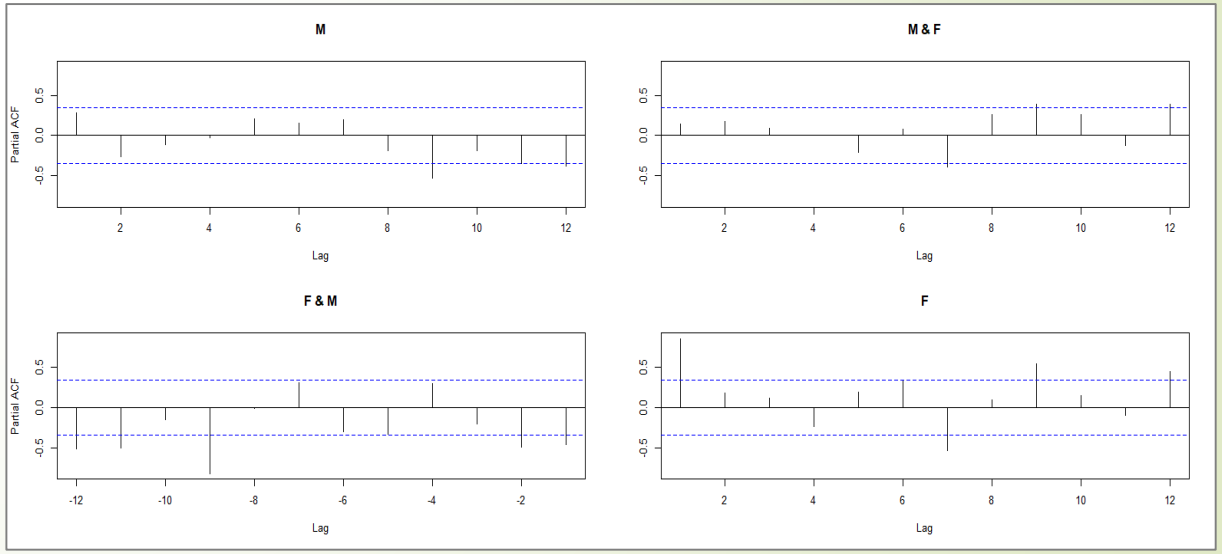




Autocorrelation and Partial Autocorrelation Functions

- The residuals appear to follow a slight AR(1) pattern
- The residual process can be fit by the following two equations:
  - $MaleError_t = -2{,}694.2080188 + 0.4739946 * MaleError_{t-1} + \varepsilon_t$
  - $FemaleError_t = -3.768.2519971 + 0.6228232 * FemaleError_{t-1} + \varepsilon_t$
- Though this occurs, since no other variable exists in this analysis, this is assumed to be the closest approximation to the real model that can be obtained





Conclusion

- We can now use Theil's F test to test the coefficients of the unemployment rate and the amount of scholarships
- 1st Test (Unemployment)
  - H_o: $Male\beta_1 = Female\beta_1$
  - H_A: $Male\beta_1 \neq Female\beta_2$
- Theil's F test gives:
  - F – Statistic: 1.7644
  - p – value: 0.1893
- 2nd Test (Scholarships)
  - H_o: $Male\beta_2 = Female\beta_2$
  - H_A: $Male\beta_2 \neq Female\beta_2$
- Theil's F test gives:
  - F – Statistic: 1.3699
  - p – value: 0.2466
- Thus, we can conclude that male and female enrollment rates do not statistically respond differently to differences in the unemployment rate or in scholarships
- Given more data, it is possible that we could have a different result

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