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U.S. Public Pension Funding and State Growth Effects

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A Research Paper

Submitted in Partial Fulfillment of the Requirements for the

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RESEARCH PAPER APPROVAL

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Professor Scott Gilbert

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AN ABSTRACT OF THE RESEARCH PAPER OF

ERIC D LENZ, for the MASTER OF SCIENCE degree in ECONOMICS at Southern Illinois University Carbondale.

TITLE: U.S. PUBLIC PENSION FUNDING AND STATE GROWTH EFFECTS

MAJOR PROFESSOR: Dr. SCOTT GILBERT

Does U.S. state pension funding affect real GDP growth rates? Do states that witness higher GDP growth also have better funded pensions? Can one expect less GDP growth when state pensions are poorly funded? My study took the funding ratio of state pension plans, the asset-to-liability ratio, and compared it with real state GDP levels. The methods I used consisted of time series panel data regression analysis using data from the BEA and the U.S. Census Bureau. When predicting changes in real GDP, I found that lagged values of data were more explanatory and a small positive coefficient existed for the funding ratio values. This can be explained as an indicator of efficient allocation of pension assets coinciding with a state's efficient allocation of public resources. An interesting implication of this relationship is the causation of one variable on another, an avenue requiring more research.

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CHAPTER 1

INTRODUCTION

From the literature on social security, we know that there exist competing claims to growth and the effect of social security. Ehrlich and Zhong (1998) found an adverse effect on growth from social security variables. However, other literature shows a positive effect on savings from social security and Barro (1989) found a positive effect of government transfers on growth. More recently, Zhang and Zhang (2004) found a positive growth effect of social security from cross-country data and from this paper I ground my research using pension funding as the predictor of real GDP growth.

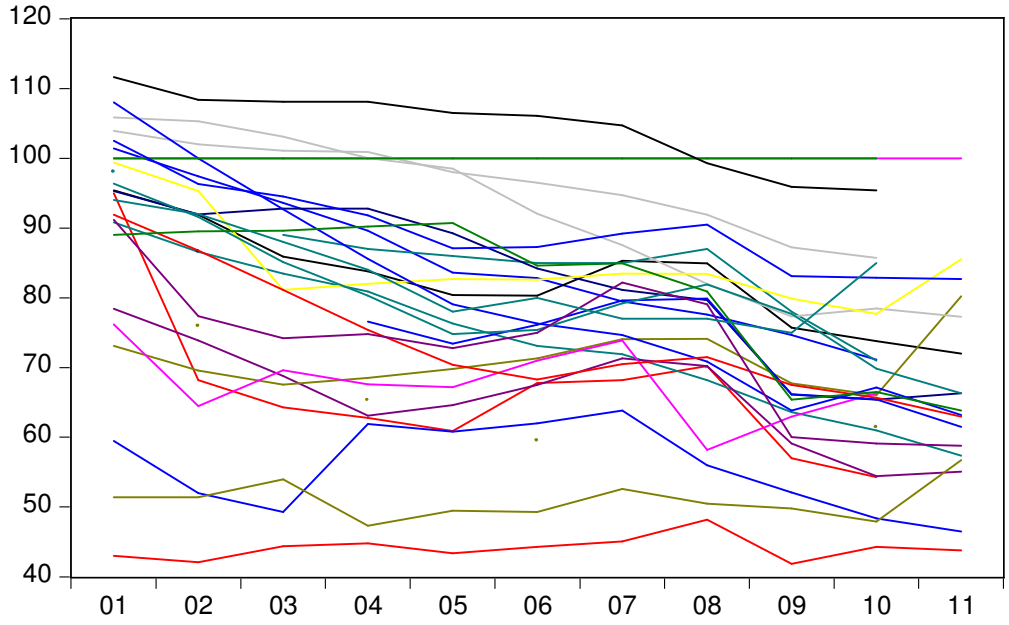
The funding ratio has been used to analyze assets and liabilities in public pension funds in order to help better allocate resources. Fund managers could typically compare this year's funding ratio with previous year's ratio or contrast their own pension fund with another state's fund. I'd like to use the variable as an indicator of funding for the public pension plan. For example, a plan which is underfunded will display a very low funding ratio and a plan which is doing exceptionally well will have a funding ratio which is high.

Turning to a state's economic growth, states which are better at allocating resources and government employee's assets more efficiently will have higher funding ratios and also higher real GDP growth. To test this hypothesis I run regressions and choose independent variables: funding ratios, total contribution, and government spending.

The pension plan data for the years 2001-2011, including the state-specific teacher plans, were found from the U.S. Census Bureau (http://www.census.gov/govs/retire/) . Specific to this pension plan data, I use the funding ratio, assets/liabilities, as the indicator of funding. Also from this source, I include the contribution into the specific teacher plan. The real GDP values per state and government spending levels are located at the Bureau of Economic Analysis (BEA) website (www.bea.gov). For this study, I used 22 state teacher pension plans, because I wanted to control for variability of asset allocation among other state plans. We'll make a general assumption for now that state pension fund managers will allocate assets the same way for teachers across different states. This is done so that the actual levels of funding may differ, but the changes over years will be approximately the same and some trend can be identified.

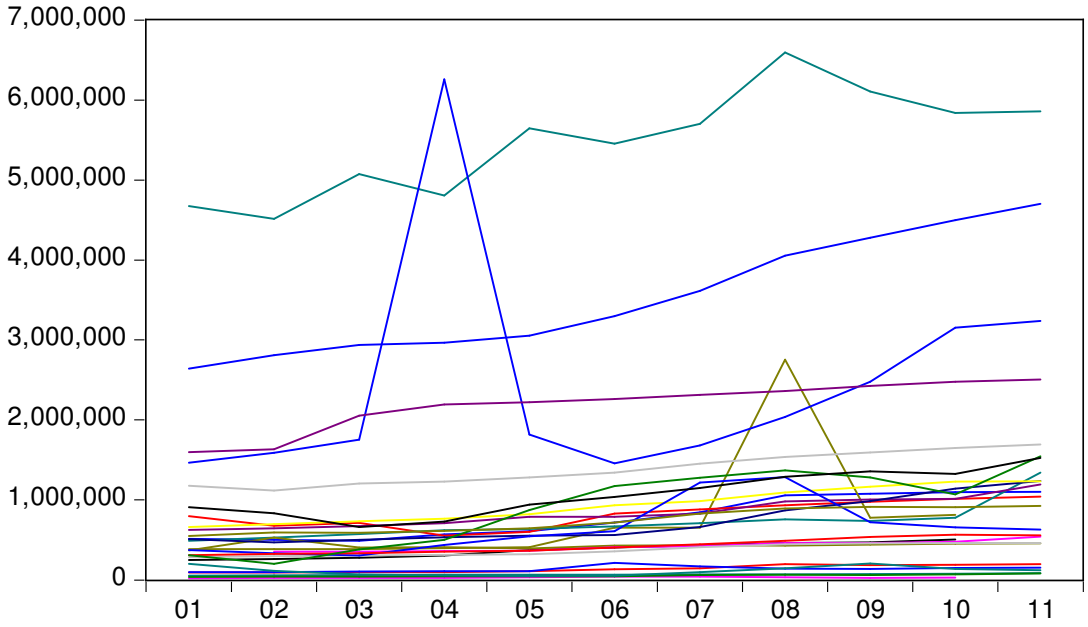
As the funded ratio, the asset to liability ratio of a pension plan, declines are U.S. state economic growth rates affected? Figure 1 below is a graph of 22 different pension plans with each colored line representing a state's teacher pension plan. With years spanning from 2001 to 2011 on the x-axis, one notices the funding ratio declining in almost every state. Does this decline in state funded pensions affect the state GDP growth rates?

Figure 1, Plot of each state's funding ratio over time



Considering contributions into the pension plan, workers are contributing more to their pensions over time, even though funding ratios (assets/liabilities) are falling. Below in figure 2 is a graph of total contributions per public pension plan.

Figure 2, Plot of total contributions per state plan over time



My hypothesis is that the funding ratio of public pension funds has an effect on real GDP growth rates. I expect the funding ratio to positively correlate to real GDP growth. The intuition is that as public pension funds become better funded, i.e. more assets relative to liabilities, GDP will be affected positively. The effect should be very small, but still noticeable.

CHAPTER 2

METHODS AND RESULTS

First, I did a normal linear regression of real GDP growth on total contributions, the funding ratio of assets/liabilities, and government spending. My panel data is set up with 10 years of data per state, so I decided to use fixed effects in the regression. By doing this, the data can be analyzed in the cross-sectional panels and give a more accurate representation of the variables. The greatest predictor from this regression is the funding ratio, what one could call the indicator of real assets. As the funding ratio increases, i.e. assets increase or liabilities decrease, the indicator of real GDP growth increases. There is a very small negative coefficient on contributions, the intuition being that as contributions increase, there is more money being taken from people leaving less for them to spend or save and GDP growth falls. Below in Table 1 is my initial regression with real GDP growth as the dependent variable and funding ratio, government and contributions the independent variables:

Table 1, Initial regression with real GDP growth and independent variables

Dependent Variable: REAL_GDP_GROWTH

Method: Panel Least Squares

Sample (adjusted): 2002 2011

Periods included: 10

Cross-sections included: 27

Total panel (unbalanced) observations: 253

Variable	Coeff.	Std. Error	t-stat	Prob.
FR_TEACHERS	0.053320	0.024135	2.2092	0.0282
CONTRIBUTION	-6.87E-07	4.79E-07	-1.4322	0.1535
GOVERNMENT	1.00E-05	0.000106	0.0948	0.9245
C	-2.319914	4.524222	-0.5127	0.6086

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.1572	Mean dependent var	1.4711
Adjusted R-squared	0.0476	S.D. dependent var	2.5311
S.E. of regression	2.4700	Akaike info criterion	4.7573
Sum squared resid	1360.6	Schwarz criterion	5.1763
Log likelihood	-571.80	Hannan-Quinn criter.	4.9258
F-statistic	1.4347	Durbin-Watson stat	2.1902
Prob(F-statistic)	0.0775		

Second, I lagged the contribution values, funding ratio values, and state government spending to see if the previous year has more explanatory power on real GDP growth than the current year. The r-squared is higher with lagged values and the variables may explain real GDP growth a little better – however, I now have a problem with the lagged funding ratio being insignificant. I can perhaps correct for this by adjusting the structure of my model a bit more at a later time. Table 2 below shows the regression results:

Table 2, Regression with cross-sectional weights and lagged variables

Dependent Variable: REAL_GDP_GROWTH
Method: Panel EGLS (Cross-section weights)
Date: 12/11/12 Time: 09:21
Sample (adjusted): 2002 2011
Periods included: 10
Cross-sections included: 27
Total panel (unbalanced) observations: 261
Linear estimation after one-step weighting matrix
White cross-section standard errors & covariance (d.f. corrected)

Variable	Coeff.	Std. Error	t-Statistic	Prob.
GOVERNMENT(-1)	4.50E-06	9.95E-05	0.045	0.963
FR_TEACHERS(-1)	0.0212	0.0332	0.637	0.524
CONTRIBUTION(-1)	-1.68E-06	1.06E-06	-1.589	0.113
C	1.2246	4.1910	0.292	0.770

Effects Specification

Cross-section fixed (dummy variables)

Weighted Statistics

R-squared	0.1948	Mean dependent var	1.5786
Adjusted R-squared	0.0937	S.D. dependent var	2.5716
S.E. of regression	2.4135	Sum squared resid	1345.5
F-statistic	1.9271	Durbin-Watson stat	2.2975
Prob(F-statistic)	0.0043		

The Durbin-Watson test statistic is fairly close to 2, so there may exist a tiny bit of serial correlation of the error terms. When I pick individual variables to lag, the regression itself doesn't become any better and the probability of the individual variables does not become more significant. For this reason, I first check for heteroscedasticity.

From the lagged variable regression, I found residuals and tested for heteroscedasticity of the error terms. Below in Table 3 are the residuals, actual and fitted values.

Table 3, Residuals with actual and fitted values

residual	actual	fitted	
2.36048	1.67534	0.68514	| . * . |
2.11768	1.65990	0.45778	| . * . |
4.82187	1.64017	3.18169	| . | * |
2.70640	1.56783	1.13856	| . |*. |
1.78111	1.50186	0.27925	| . * . |
1.10462	1.44160	-0.33698	| . * . |
0.30971	1.35231	-1.04260	| .*| . |
-5.13102	1.21833	-6.34935	| * . | . |
2.27415	1.19098	1.08316	| . |*. |
-0.76207	1.15346	-1.91554	| .*| . |
3.79507	1.66467	2.13040	| . |*. |
-2.24263	1.46895	-3.71158	| * | . |
5.07985	1.43793	3.64193	| . | * |
-1.06646	1.42425	-2.49071	| * | . |
5.31500	1.40681	3.90819	| . | .* |
2.13096	1.44661	0.68436	| . * . |
0.84422	1.44204	-0.59782	| . * . |

Figure 3, Residuals with actual and fitted values per state pension plan

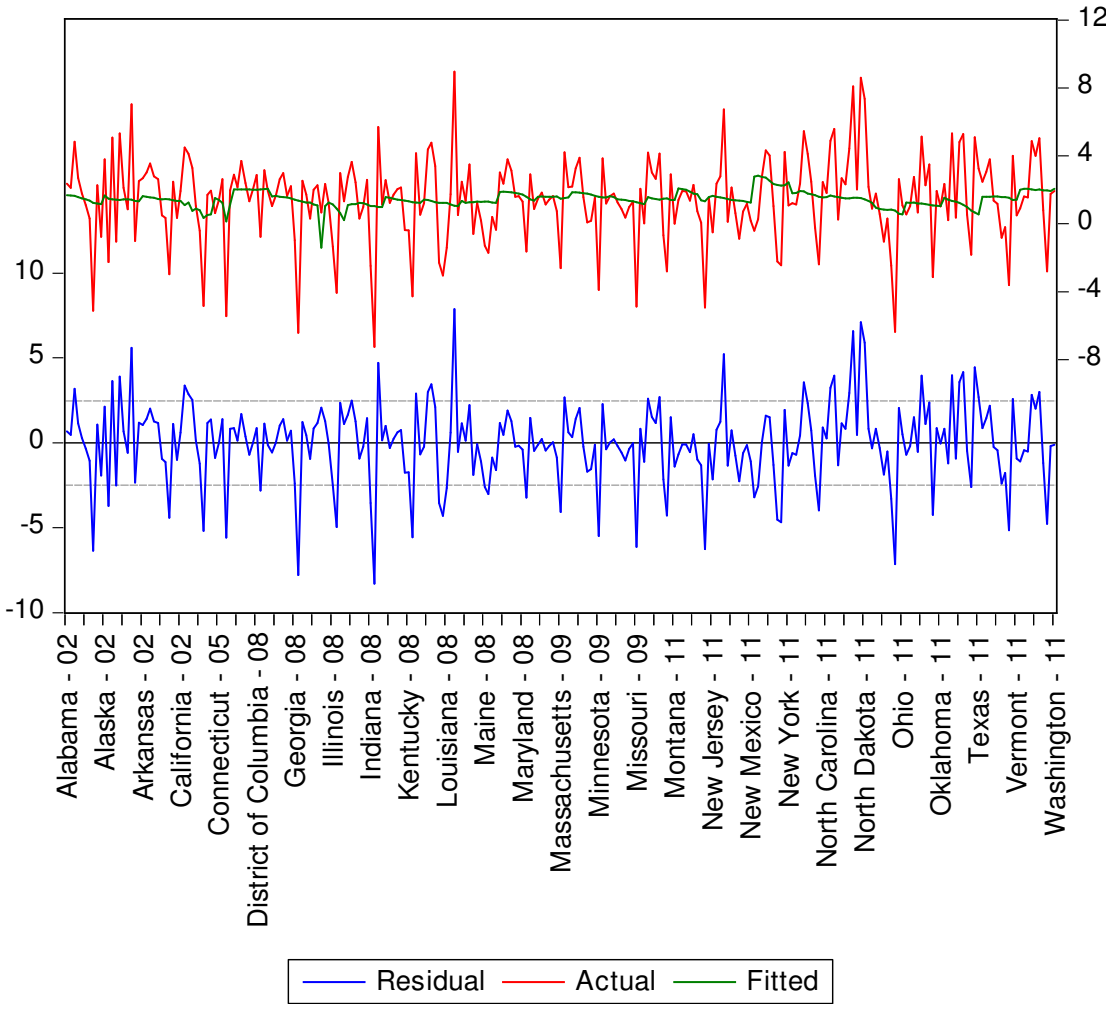


Figure 3 above shows that from the residual graph, it's not clear whether a pattern exists.

Testing for homoscedasticity yields significant results for the squared funding ratio errors and this means that the squared values of the funding ratio and the funding ratio help explain the squared residuals best. Therefore the coefficients of the funding ratio are not zero and we reject the null hypothesis that there is homoscedasticity. Below in Table 4 is a heteroscedasticity test using least squares regression:

Table 4, Testing for Heteroscedasticity using least squares regression
Dependent Variable: RESLAG^2
Method: Panel EGLS (Cross-section weights)
Sample (adjusted): 2002 2011
Periods included: 10
Cross-sections included: 26
Total panel (unbalanced) observations: 244
Linear estimation after one-step weighting matrix

Variable	Coeff.	Std. Error	t-Stat	Prob
GOV(-1)*FR(-1)	1.61E-06	3.67E-06	0.439	0.66
FR(-1)*CONT(-1)	-3.81E-08	8.89E-08	-0.428	0.66
GOV(-1)*CONT(-1)	9.52E-12	4.73E-11	0.201	0.84
GOV(-1)^2	6.14E-10	1.16E-09	0.528	0.59
FR^2	-0.001	0.0010	-1.441	0.15
CONT(-1)^2	-4.61E-13	5.39E-13	-0.854	0.39
GOV(-1)	-0.0002	0.0002	-0.835	0.40
FR(-1)	0.2025	0.0877	2.308	0.02
CONT(-1)	4.95E-06	6.86E-06	0.721	0.47

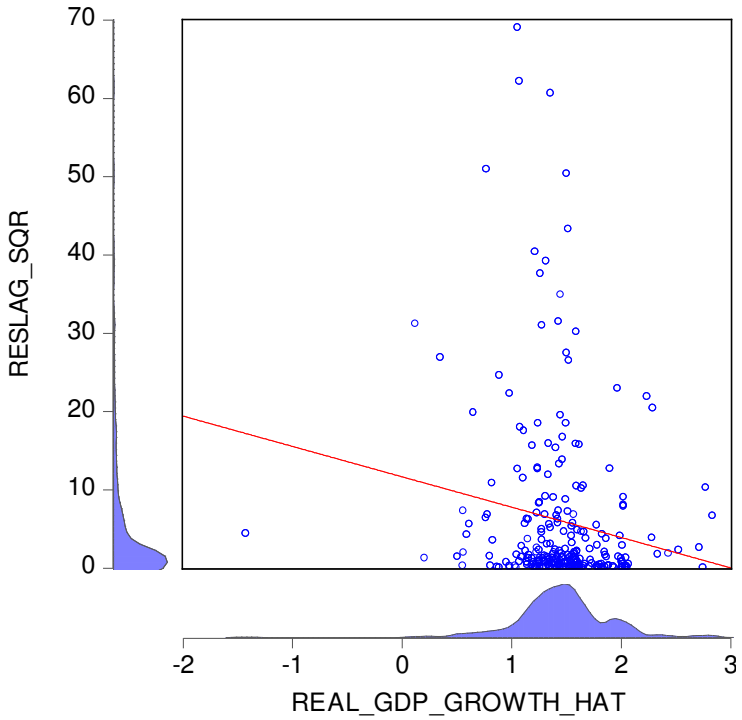
Weighted Statistics

R-squared	0.0324	Mean dependent var	9.03
Adjusted R-squared	-0.0004	S.D. dependent var	11.4
S.E. of regression	11.746	Sum squared resid	324
Durbin-Watson stat	2.0424		

Unweighted Statistics

R-squared	-0.0014	Mean dependent var	7.45
Sum squared resid	38731	Durbin-Watson stat	1.90

Figure 4, plot of lagged, squared residuals on real GDP grow

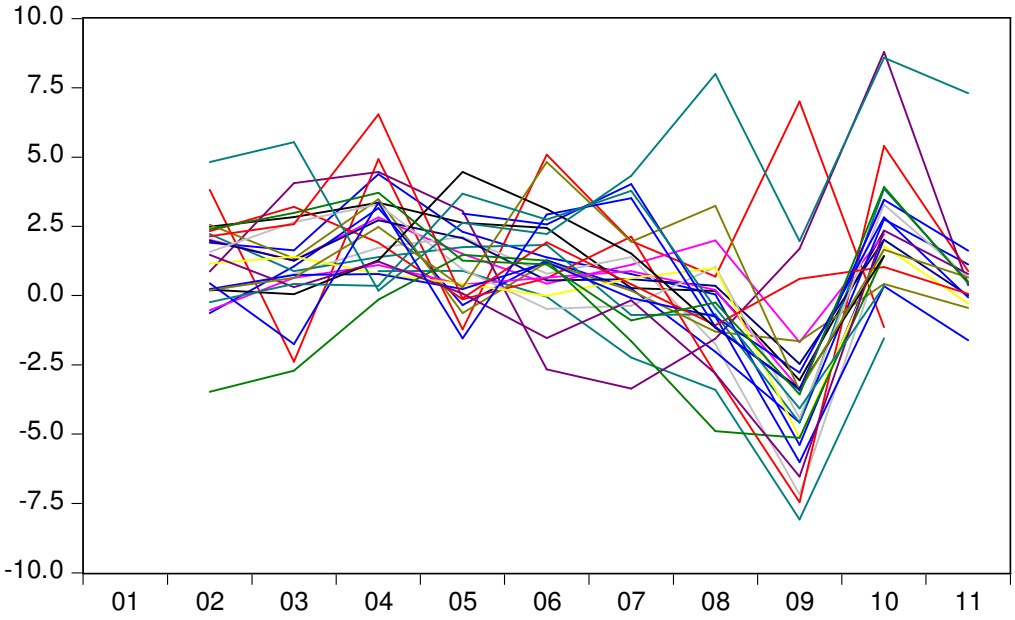


In Figure 4 above, a plot of the squared lagged residuals with predicted real GDP grow reveals that within the range of 1-2% growth, one can expect more variation of the error terms. If I wanted to adjust for this heteroscedasticity of errors, perhaps I can add more explanatory variables like state revenue or social security as defined by contributions/income. Due to this variation, my initial lagged regression does use White standard errors which should help correct for heteroscedasticity. In any case, there does seem to be a link between the funding ratio and the errors.

With a weighted cross-section analysis, my R-squared statistic is 0.195. With an unweighted cross-section analysis, the R-squared statistic is 0.159. For these reasons, I believe a weighted-analysis is more integral for an overall analysis.

Because the Durbin-Watson test statistic was so close to 2, I don't think there is auto-correlation or serial correlation of the errors over time. Below in Figure 5 is a plot of the residuals from each plan over time:

Figure 5, plot of residuals for each public pension plan over time



However, when we look at this graph over time, one notices a pretty remarkable pattern. The residuals look stationary until the year 2007 and then they all dip down into the negative range in 2009 and finally rise up into the positives after 2009. Given this striking pattern, I hypothesize some serial correlation. In Table 5 below, there is included an AR(1) model of the residuals from the lagged variable model:

Table 5, AR(1) model of lagged residuals

Dependent Variable: RESLAG
Method: Panel Least Squares
Sample (adjusted): 2003 2011
Periods included: 9
Cross-sections included: 26
Total panel (unbalanced) observations: 219

Variable	Coeff.	Std. Error	t-Statistic	Prob.
RESLAG(-1)	-0.004068	0.072522	-0.05609	0.9553
C	0.703222	0.183839	3.82520	0.0002

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.18777	Mean dependent var	0.70019
Adjusted R-squared	0.07778	S.D. dependent var	2.70811
S.E. of regression	2.60066	Akaike info criterion	4.86441
Sum squared resid	1298.58	Schwarz criterion	5.28224
Log likelihood	-505.65	Hannan-Quinn criter.	5.03315
F-statistic	1.7071	Durbin-Watson stat	2.20193
Prob(F-statistic)	0.0225		

Considering an AR(1) model of the residuals from the lagged regression, the error terms do not seem to be correlated with their lags and the R-squared value is very small. I also decided to run an LM-test with the residuals on their lags and independent variables. The results are similar with the lagged coefficient of the residual being insignificant. With this in mind, I don't believe there to be any serial correlation of the error terms. Also, I've included a new lagged residual regression for an LM test in Table 6 below:

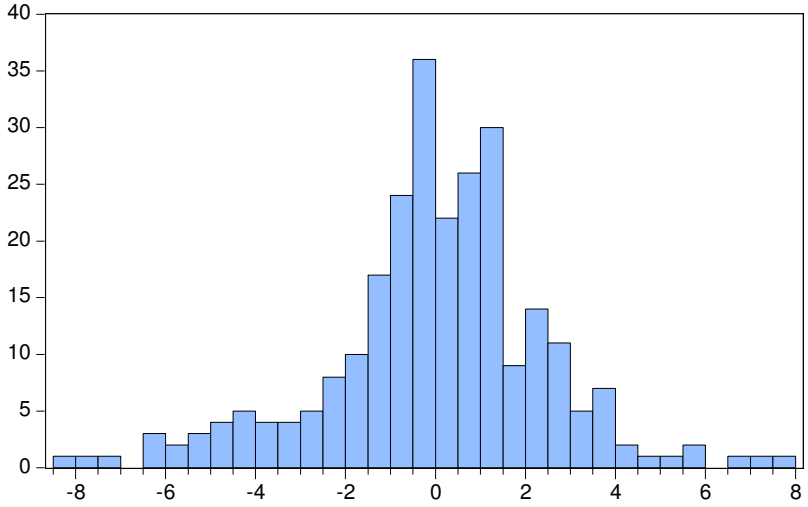
Table 6, Regression model with lagged residual

Dependent Variable: RESLAG
Method: Panel Least Squares
Sample (adjusted): 2003 2011
Periods included: 9
Cross-sections included: 26
Total panel (unbalanced) observations: 219

Variable	Coeff.	Std. Error	t-Stat	Prob.
GOV(-1)	-1.00E-05	0.000128	-0.078	0.937
FR(-1)	0.003942	0.030552	0.129	0.897
CONTRIBUTION(-1)	-1.03E-06	5.60E-07	-1.843	0.066
RESLAG(-1)	-0.018088	0.074035	-0.244	0.807
C	1.761544	5.612788	0.313	0.754
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.20862	Mean dependent var		0.700
Adjusted R-squared	0.08720	S.D. dependent var		2.708
S.E. of regression	2.58734	Akaike info criterion		4.865
Sum squared resid	1265.23	Schwarz criterion		5.330
Log likelihood	-502.804	Hannan-Quinn criter.		5.053
F-statistic	1.71812	Durbin-Watson stat		2.210
Prob(F-statistic)	0.01743			

A histogram of the residuals reveals that they appear normally distributed, though perhaps somewhat fat-tailed in Figure 6 on the next page.

Figure 6, Distribution plot of residuals from Table 6 regression model



Can we make some inferences about the population from the sample? Is there some trend/behavior that holds in the real GDP growth rates? Does the lagged value of real GDP growth somehow explain the current value of real GDP growth? To test the hypotheses, I set up an AR(1) model of the real GDP growth values, however, even with high probabilities of significance, the R-squared statistic is extremely small (see Table 7 on the next page).

Table 7, Panel least squares regression of dependent variable on it's lag

Dependent Variable: REAL_GDP_GROWTH

Method: Panel Least Squares

Sample (adjusted): 2003 2011

Periods included: 9

Cross-sections included: 60

Total panel (balanced) observations: 540

Variable	Coeff.	Std. Error	t-Statistic	Prob.
RGDP_GROWTH(-1)	0.1256	0.0450	2.7878	0.0055
C	1.3194	0.1375	9.5913	0.0000

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.125	Mean dependent var	1.5189
Adjusted R-squared	0.015	S.D. dependent var	2.7515
S.E. of regression	2.729	Akaike info criterion	4.9524
Sum squared resid	3569.7	Schwarz criterion	5.4372
Log likelihood	-1276	Hannan-Quinn criter.	5.1420
F-statistic	1.142	Durbin-Watson stat	2.1748
Prob(F-statistic)	0.226		

The R-squared value is 0.125, but the coefficient value of the lag is 0.125. One might expect some sort of explanatory power of the lag – if we experience growth in one year, maybe the chance of experiencing growth in the next year is higher. However, judging by the R-squared value, we must abandon this hypothesis.

My goals for further research are to test for stochastic trends in state real GDP growth, test the unit root hypothesis and determine whether variables move together (cointegration). Also, I have concerns of endogeneity of the variables which may be alleviated with a 2-stage LS regression to be completed in the near future. Another avenue of analysis is using individual states and comparing/contrasting. Also, there may exist public pension plan data going further than ten years back, and that could be valuable for long-run growth analysis.

CHAPTER 3

CONCLUSION

With a robust framework of analysis introduced from an Econometrics course this semester, I was able to carry out a bevy of statistical tests on my data. The coefficients of the funding ratio and contribution seemed significant, but with a weighted analysis, they become less so. The error terms exhibit some heteroscedasticity, however, they are not serially correlated with one another. The lagged values of the dependent variable do not cause future values as observed by two statistical tests. Also, measures of cointegration lie in wait for future analysis and the unit root hypothesis may not be valid.

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Bureau of Economic Analysis data: http://www.bea.gov/regional/downloadzip.cfm

U.S. Census Bureau data: http://www.census.gov/govs/retire/

VITA

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