Forecasting United States federal employment changes with presidential and congressional majority party control

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Abstract

Political rhetoric suggests a strong connection between United States federal government expenditure growth and the party controlling the legislature and executive. Time series forecasting of federal employment compensation expenditures provide a means of evaluating political effects, including how they may be effected by economic cycles. However, political and cyclical effects are a small, though not insignificant, driver of federal government employment compensation growth.

1 Introduction

Political ideology amongst the major parties in the United States can largely be defined by their stance on the size and scope of government. As such, growth of agencies and programs would be expected to be shaped by the dominant party. By assumption, we would predict health and welfare program to suffer under Republican control of congress and the presidency, while the reverse would be expected to be true under Democratic control. Further, we might expect stronger countercyclical effects under Democratic administrations than under Republican. In this paper, we consider the impact of federal political party control on federal employment compensation. In particular, we model and forecast US federal nondefense employment compensation growth using several tools of time series analysis. In stages, we use and evaluate models with solely nondefense compensation, another using defense compensation, and yet another in which we include political party control and recession indicators. We expect party rhetoric to match actual effects, with nondefense employment expenditures growing at a slower, or even negative, rate under a Republican controlled federal government and the largest growth under Democratic governments. We predict an attenuated effect when Republicans control the House, Senate, or Presidency but not all three. We expect there to be a strong countercyclical effect under Democratic control, but little or none under Republican administrations.

2 Literature Review

While much work has been done in projecting future federal expenditures, in large part as a function of the congressional budget office and similar executive agencies, little has been done in our specific area. Combining our three relevant areas of interest, federal compensation, modeling with an eye towards forecasting, and incorporating exogenous political factors. However, research touching on some of these factors do exist, and provide some guidance in constructing our own model. An interest in the spending patterns of government dates back to the origins of economics as a discipline, though much of work in this area predates modern tools of economics and provides little assistance now. However, an article by Peroff and Podolak-Warren (1979) on expenditure priorities in the United States took a detailed look at the tradeoff made between defense and federal health spending. They suggest some possible concerns with the measures of federal spending used. In particular, they note large differences between allocations, primarily made by congress, and realized expenditures. It's noted that a large part of the discrepancy is the executive's ability to set priorities amongst their agencies. This points to a need to include political party control of the presidency,along with the relevant interactions with congress, into our political effects model.

Interestingly, Peroff and Podolak-Warren (1979) finds a trade off in allocation of funds between defense and health, but not, generally, in actual expenditures. When considering our own model, which does not include allocations, our political effects may be attenuated in years of a politically split federal government.[1]

A few papers look at political effects on federal allocations, which here serve as a proxy for actual expenditures. Berry et al. (2010) demonstrates that congressional Democrats allocate funds disproportionately to districts and states with a preponderance of Democratic voters. While unsurprising, this does provide further credence to our theory that political ideology influences funding decisions. In all, prior work informs and aids us in this article, but doesnt provide a definitive model to emulate. However, the relatively simple methods used to evaluate political and recessionary effects on nondefense employment compensation expenditures suit the straightforward nature of the effect of interest.

3 Data Sources and Summary

The primary time series of interest is United States federal government consumption expenditures on nondefense compensation of general government employees.[2] This and all other data are quarterly, and range from the first quarter of 1955 to the first quarter 2015, except where otherwise noted. This time series is seasonally adjusted. Later, when considering multivariate models, we'll be incorporating a similar time series of defense employment compensation to aid in forecasting nondefense compensation. Both time series are in 2015 dollars.

In addition, we'll be including times series of political control of the US federal government. Indicators of Republican control of the House, Senate

[1] Allocations are primarily not included as it would constrain us to only annual observations, reducing our available observation dramatically.

[2] Federal Reserve Economic Data - series W130RC1Q027SBEA

and Presidency, along with interaction terms, will be used to account for potential ideological effects on nodefense compensation spending.[3] Lastly, we'll be incorporating a time series of recessions, represented by a dichotomous variable.[4][5]

4 Modeling, Estimation and Forecasting

4.1 Univariate modeling

Initially, we considered a model solely using the nondefense employment expenditure time series.[6] A look at the time series, with an upward trend, suggested it was not autocovariance stationary. This was further confirmed through an augmented Dickey-Fuller test and a further look at the data confirmed this.[7] Differencing the time series once appears, per the ADF and a look at the post differencing data, to make the series autocovariance stationary. [8] Alternative approaches, including using residuals from a linear trend model and using percentage change from previous values, yielded poorer results.[9]

A look at the autocorrelation and partial autocorrelation functions then provided a good starting point in estimating a suitable Autoregressive-Moving Average model. The initial ACF and PACF graphs, with large periodic spikes tapering off in the ACF and little persistence in the PACF, suggested an AR(4) or similar specification.[10] Comparison of Akaike Information Criteria numbers from similar ARMA processes further supported selection of AR(4).[11] A look at the residuals from the AR(4) process, along with the ACF and PACF graphs, strongly suggested a white noise process.[12]

This resulted in the following model

[3] Political party control data were initially derived from Wikipedia, but confirmed through Congressional and Executive government websites.

[4] FRED - series USRECQ

[5] Appendix: Table 1

[6] Appendix: Graph 1

[7] Appendix: Graph 2

[8] Appendix: Graph 3

[9] Appendix: Graph 4, Graph 5

[10] Appendix: Graph 6

[11] Testing included AR() and MA() 1 through 20 and ARMA(1,1) through ARMA(20,20)

[12] Appendix: Graph 7, Graph 8

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \phi_3 Y_{t-3} + \phi_4 Y_{t-4} + \varepsilon_t$$
$$\varepsilon_t \sim WN(0, \sigma^2)$$

Where Y_t is differenced nondefense employment expenditures and is determined by the four preceding lagged values of differenced nodefense employment expenditures and a white noise process error.

In the interest of being thorough we considered time dependent volatility. A glance at the squared residuals from the AR(4) process suggests a nonconstant variance, and the related ACF and PACF graphs lend further credence to the possibility that current period volatility may in part be a function of previous period volatility.[13]GARCH(1,1) and ARCH(1) processes both appear to make good inroads in addressing any potential issues with time dependent variance. However, the issue appears sufficiently small to leave out offurther modeling and forecasting.

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \phi_3 Y_{t-3} + \phi_4 Y_{t-4} + \varepsilon_t$$
$$\varepsilon_t \; WN(0, \sigma_t^2)$$
$$\text{where } \sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 + e_t$$

4.2 Univariate forecasting

Forecasting ahead 3 years suggests fluctuating but increasing federal expenditures of nondefense employment compensation. The rate of increase and periodicity are about on par with that of the decade preceding the great recession. This time period might prove a more useful comparison, as the great recession showed uncharacteristic volatility.[14]

Evaluating the accuracy of the model's prediction we used a truncated nondefense expenditure time series to predict the last three years of observed values. Interestingly, the prediction fails to decrease as far as the actual observations, but predicted and actual values meet by the end of the comparison time frame. Providing further support to the model, the observed values are well within the confines of the forecast's 95% confidence interval.[15]

[13]Appendix: Graph 9
[14]Appendix: Graph 10
[15]Appendix: Graph 11

4.3 Multivariate modeling

In an effort to improve the accuracy of our model, we then incorporated the effect of the other major category of federal employment expenditures, defense compensation.[16] Prior to incorporating defense employment compensation expenditures, we transformed the original data through differencing to be covariance stationary. [17] Performing ADF tests at each stage, we found that the defense expenditure time series required differencing twice before it was covariance stationary.[18]

Using Vector Autoregression we found a VAR(4) process provides the lowest model AIC. Contrary to our initial suspicion that previous values of defense employment expenditures would affect current period nondefense expenditures, it appears they do not. No series lagged values provide statistically significant explanatory power on the other series, though same series lagged values are largely statistically significant. [19]

$$Y_t = \phi_1 0 + \phi_1 1 Y_{t-1} + \phi_1 2 Y_{t-2} + \phi_1 3 Y_{t-3} + \phi_1 4 Y_{t-4} + \theta_1 1 X_{t-1} + \theta_1 2 X_{t-2} + \theta_1 3 X_{t-3} + \theta_1 4 X_{t-4} + \varepsilon_1 t$$

$$X_t = \phi_2 0 + \phi_2 1 Y_{t-1} + \phi_2 2 Y_{t-2} + \phi_2 3 Y_{t-3} + \phi_2 4 Y_{t-4} + \theta_2 1 X_{t-1} + \theta_2 2 X_{t-2} + \theta_2 3 X_{t-3} + \theta_2 4 X_{t-4} + \varepsilon_2 t$$

Where $Y_t$is differenced nondefense expenditures and X_t is double difference defense expenditures

4.4 Multivariate forecasting

After estimating the VAR(4) model, we forecasted 3 years forward from the first quarter 2015 using predicted values from the model.[20] The nondefense forecast appears approximately on par with the previous univariate forecast.[21] Notably, the double differenced defense expenditures show greater uncertainty in the forecasts, likely due to the relatively high variance of the original time series.

[16] Appendix: Graph 12

[17] Appendix: Graph 13, Graph 14

[18] Appendix: Graph 15

[19] Appendix: Table 2

[20] Appendix: Graph 16

[21] Taking into account the AR(4) forecast was transformed back to nondefense compensation in billions of dollars, whereas the VAR(4) forecast, due to the structure of the R VAR() function, shows only the forecasted change from the previous period.

In evaluating the forecast we used the VAR(4) process applied to a truncated series to compare the forecasting accuracy with 3 years of recent observations.[22] We see that nondefense changes in federal compensation track roughly with the predicted changes, with all values well within the 95% confidence interval. In contrast, observed changes in defense employment compensation display much more volatility than predicted, with one of the twelve values exceeding the 95% confidence interval.

From this, it appears that nondefense predictions from AR(4) and VAR(4) are comparable. Given slight improvements in forecasting accuracy, as well as an interest in using the simplest reasonable model, it appears that the univariate model is preferable to the multivariate model.

4.5 Univariate with exogenous factors modeling

To evaluate the effect of contemporaneous effects from recessions and political party control of the federal government we estimated a simplified version of an autoregressive-moving average with exogenous variables model as suggested by Hyndman (2010). Here we first estimated

$$Y_t = \delta_0 + \delta_1 R_t + \boldsymbol{P} \sum_{i=2}^{n} \delta_{i,t} + \epsilon_t$$

Where $\boldsymbol{P}$ is a vector of dichotomous variables indicating republican party control of the house, senate, presidency, and their interactions. R is a dichotomous recession indicator. Y_t is the differenced Nondefense compensation time series. We then used the residuals of ϵ_t to estimate the ARMA() process. We compared models with only recessions, with political effects, and with interactions between political effects and recessions. We selected the model with political effects and uninteracted recessions as party control had no statistically significant impact in countercyclical spending.[23] Notably though, when including political party control and recessions, only Republican House control and joint Republican House and Presidencies have a reasonably statistically significant effect individually on nondefense employment growth.

A look at the autocorrelation and partial autocorrelation functions for the exogenous variable regression suggested an ARX(4) process, though the

[22] Appendix: Graph 17

[23] Appendix: Table 3

pattern appears less distinct than with the earlier univariate model.[24] Comparison of ACF and PACF graphs, along with model AICs suggests marginal improvement by selecting the ARMAX(4,3) process rather than ARX(4).[25]

$$\epsilon_t = \phi_0 + \phi_1\epsilon_{t-1} + \phi_2\epsilon_{t-2} + \phi_3\epsilon_{t-3} + \phi_4 epsilon_{t-4} + \theta_1\varepsilon_{t-1} + \theta_2\varepsilon_{t-2} + \theta_3\varepsilon_{t-3} + \varepsilon_t$$

Where ϵ_t is the residual value from the OLS estimate using exogenous variables.

4.6 Univariate with exogenous factors forecasting

A comparison of the two models, in their projections for the next three years, show some differences. The ARMAX(4,3) process forecasts significantly more volatility in future changes to nondefense employment compensation expenditures relative to the ARX(4) process forecast.[26] Using truncated time series to forecast the last three years of changes to nondefense compensation shows that the ARX(4) process better predicts the direction and magnitude of the observations.[27]

5 Conclusion

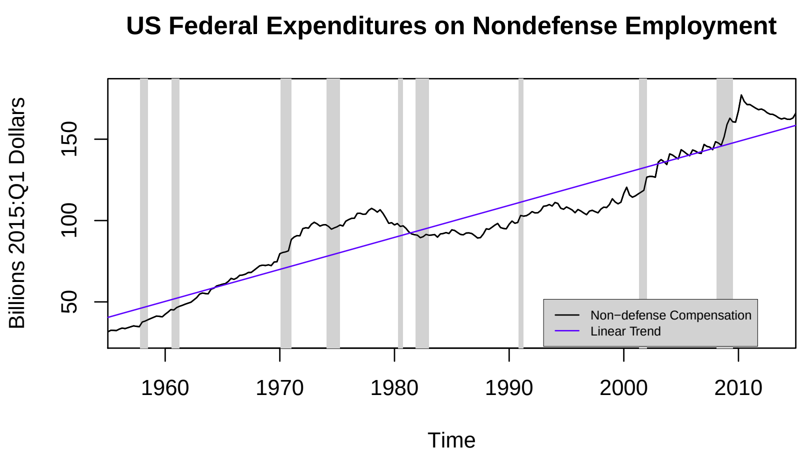
After comparing results from the univariate, multivariate, and univariate with exogenous factors models we concluded that out ARX(4) process with uses contemporaneous political and recession indicators provides the most accurate forecast of US federal nondefense employment compensation growth. In considering political factors, we found statistically marginal effects. It appears House control by Republicans decreases compensation growth by approximately $1 billion per quarter. But under a Republican presidency this effect is offset, with compensation growth decreasing slightly or potentially increasing relative to a Democratic administration. Control of the Senate appears to have no statistically significant impact on compensation growth, nor does a unified federal government. Under some specifications, there appeared to be a large countercyclical effect, with nondefense compensation increasing

[24] Appendix: Graph 18
[25] Appendix: Graph 19, Graph 20
[26] Appendix: Graph 21, Graph 22
[27] Appendix: Graph 23, Graph 24

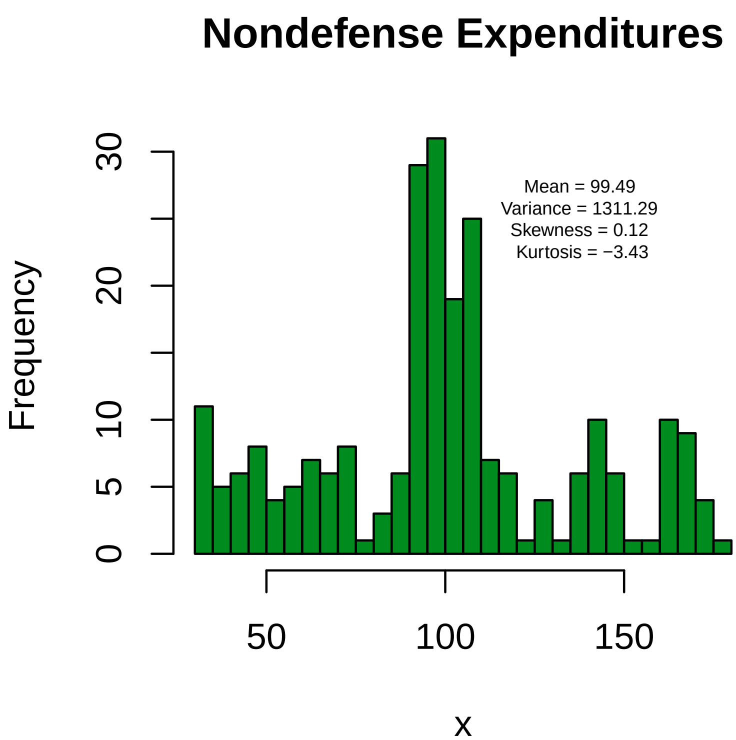
in the range of \$688 million to \$1.9 billion. Overall though, our exogenous factors added a significant but relatively small amount of explanatory power to our predictions.

6 Appendix

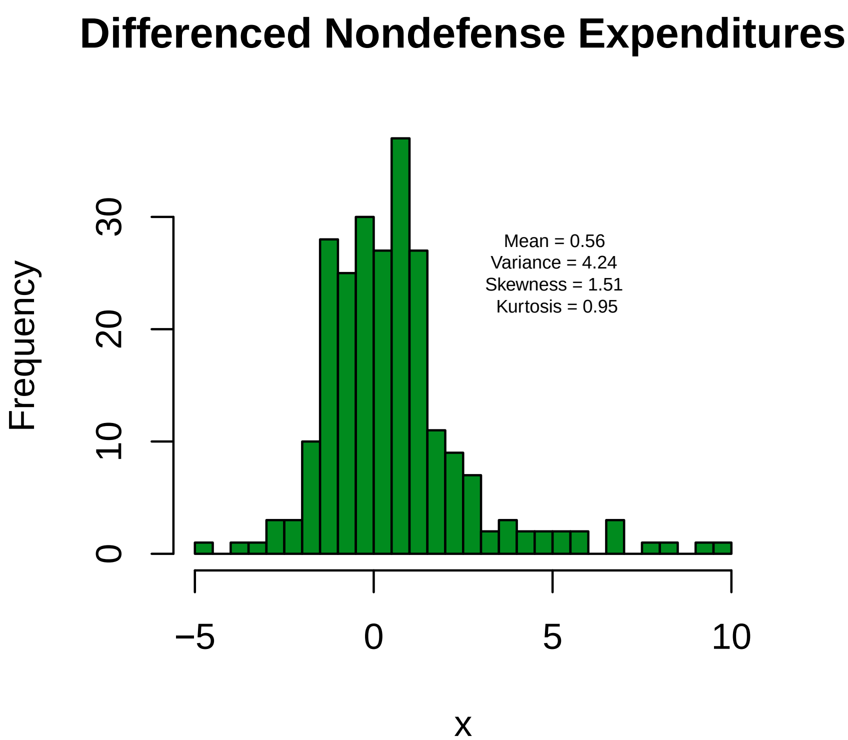
6.1 Graphs



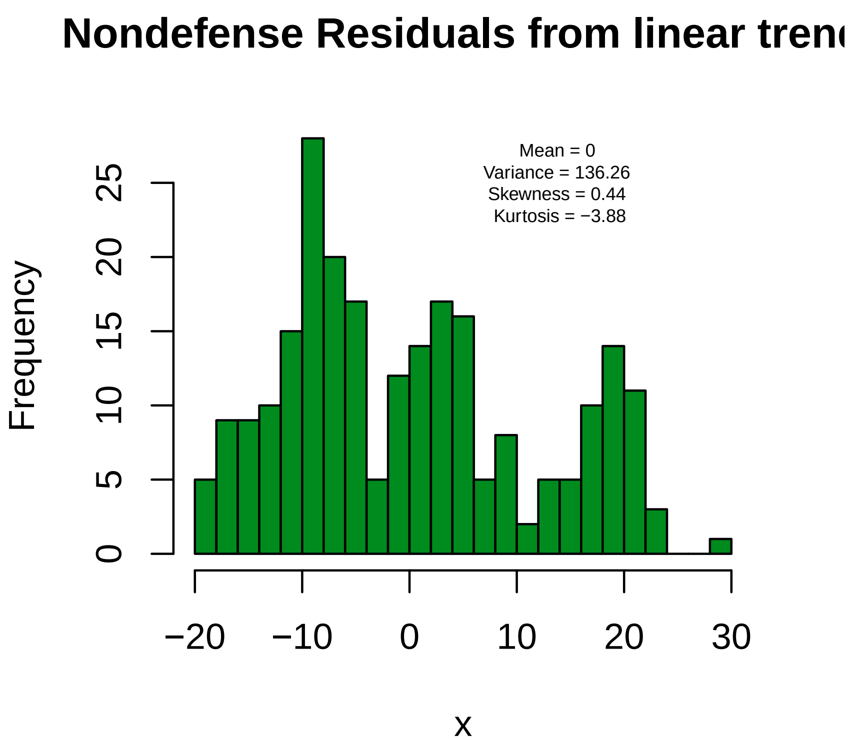
1


Nondefense Expenditures
Mean = 99.49
Variance = 1311.29
Skewness = 0.12
Kurtosis = −3.43
Frequency
0
5
10
20
30
50
100
150
x

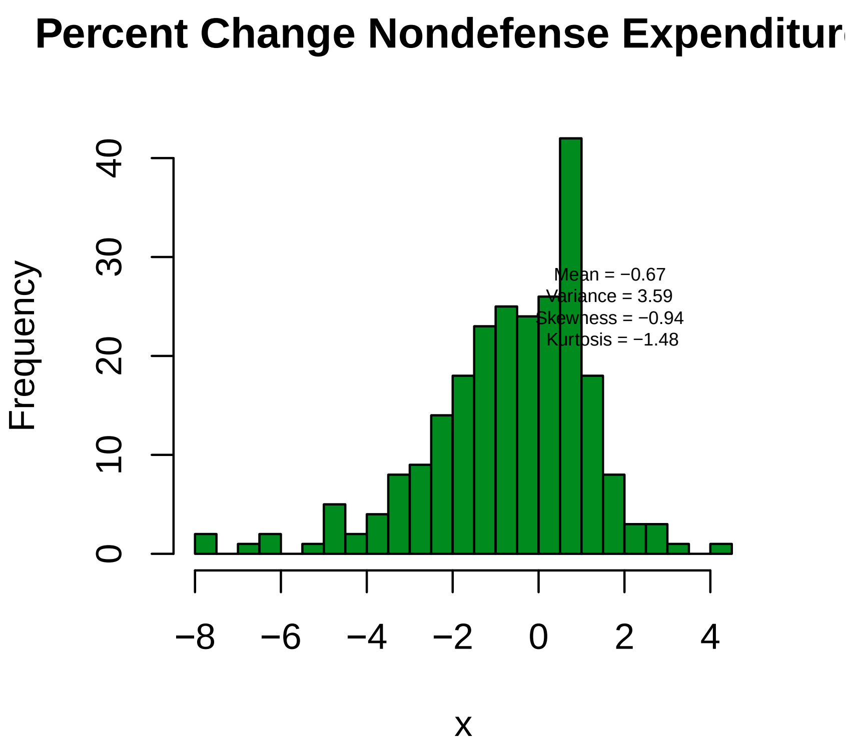
2


Differenced Nondefense Expenditures
Mean = 0.56
Variance = 4.24
Skewness = 1.51
Kurtosis = 0.95
Frequency
0
10
20
30
−5
0
5
10
x

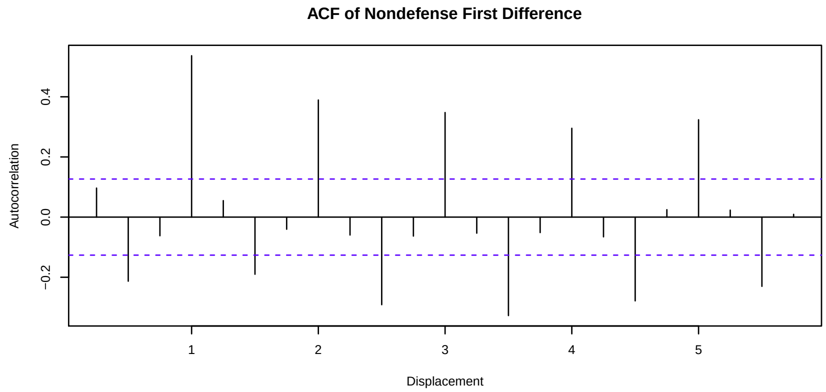
3

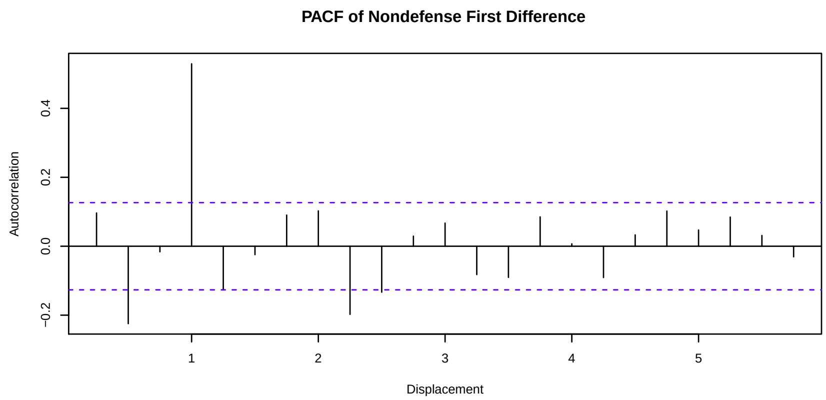

Nondefense Residuals from linear trend
Mean = 0
Variance = 136.26
Skewness = 0.44
Kurtosis = −3.88
Frequency
0
5
10
15
20
25
−20
−10
0
10
20
30
x

4

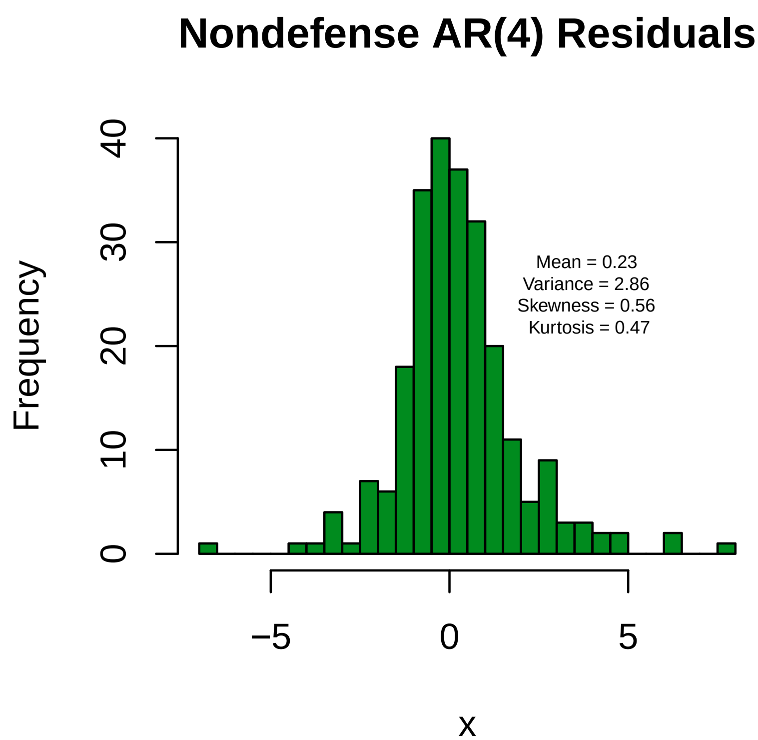

Percent Change Nondefense Expenditur
Frequency
0
10
20
30
40
Mean = −0.67
Variance = 3.59
Skewness = −0.94
Kurtosis = −1.48
−8
−6
−4
−2
0
2
4
x

5

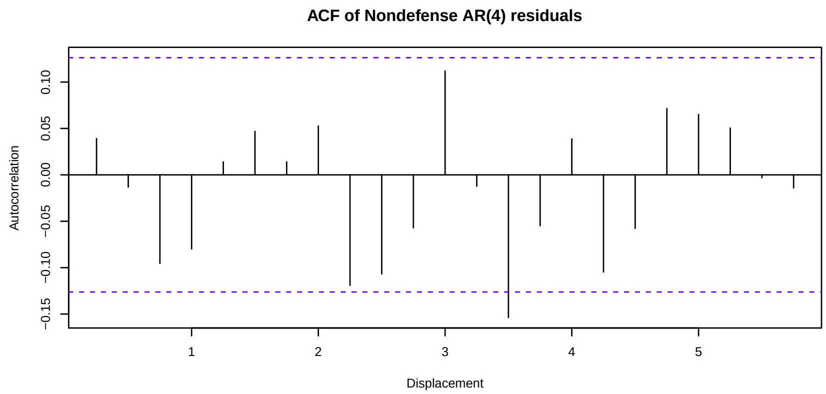

ACF of Nondefense First Difference
Autocorrelation
Displacement

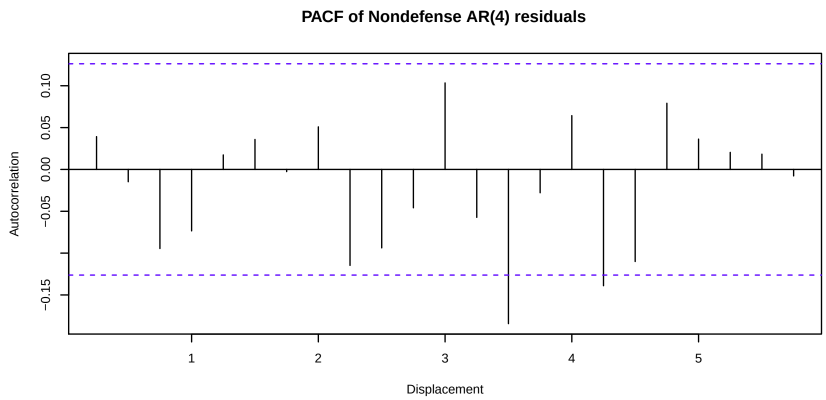

PACF of Nondefense First Difference
Autocorrelation
Displacement

6

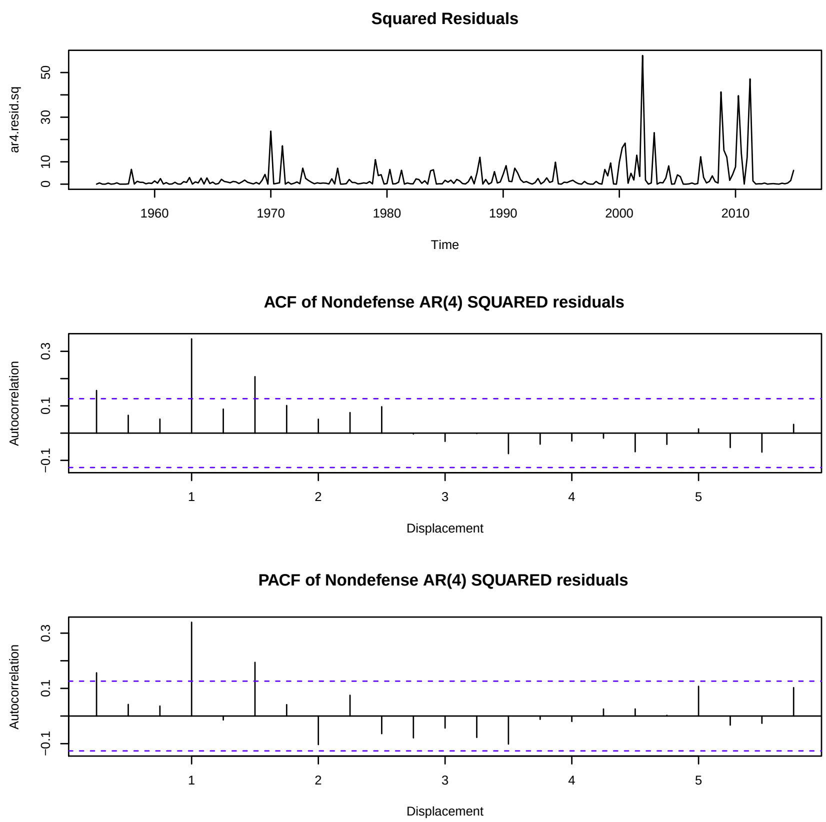

Nondefense AR(4) Residuals
Frequency
0
10
20
30
40
Mean = 0.23
Variance = 2.86
Skewness = 0.56
Kurtosis = 0.47
−5
0
5
x

7

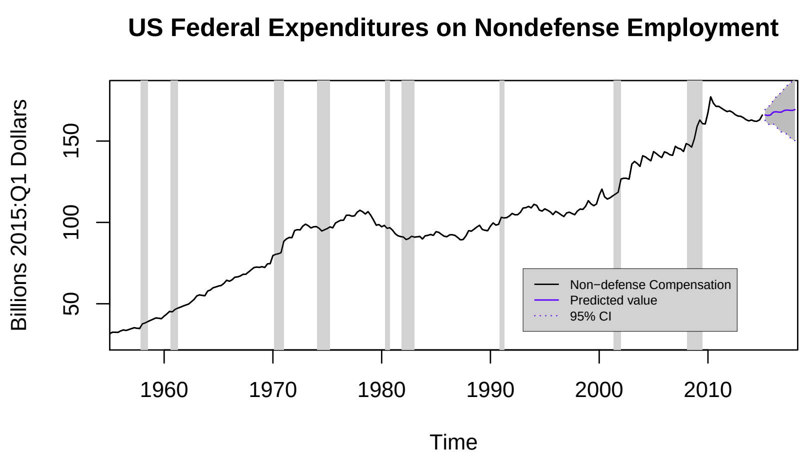

ACF of Nondefense AR(4) residuals
Autocorrelation
−0.15
−0.10
−0.05
0.00
0.05
0.10
1
2
3
4
5
Displacement


PACF of Nondefense AR(4) residuals
Autocorrelation
−0.15
−0.05
0.00
0.05
0.10
1
2
3
4
5
Displacement

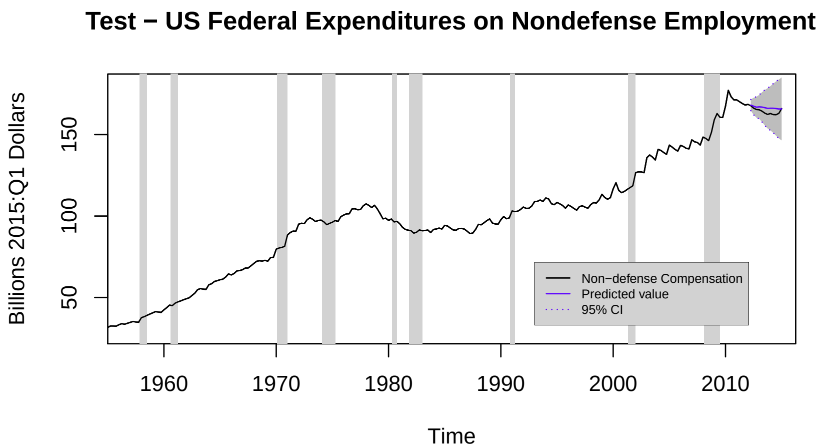
8


Squared Residuals
ar4.resid.sq
0
10
30
50
1960
1970
1980
1990
2000
2010
Time
ACF of Nondefense AR(4) SQUARED residuals
Autocorrelation
−0.1
0.1
0.3
1
2
3
4
5
Displacement
PACF of Nondefense AR(4) SQUARED residuals
Autocorrelation
−0.1
0.1
0.3
1
2
3
4
5
Displacement

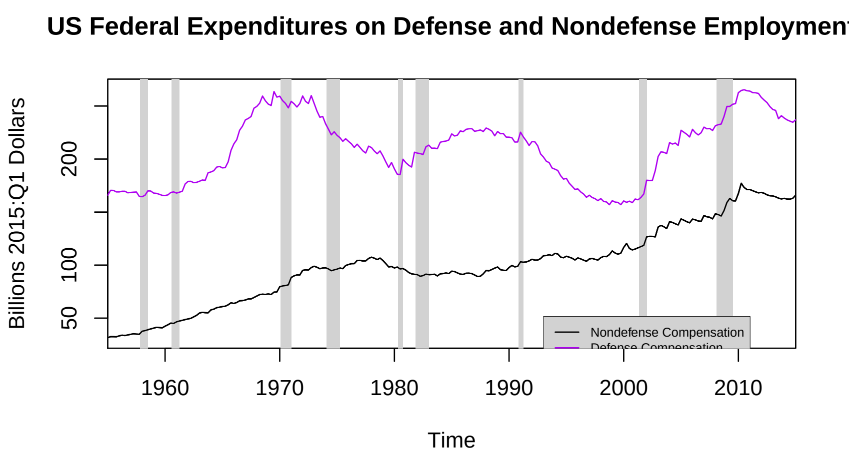
9


US Federal Expenditures on Nondefense Employment
Billions 2015:Q1 Dollars
50
100
150
1960
1970
1980
1990
2000
2010
Time
Non−defense Compensation
Predicted value
95% CI

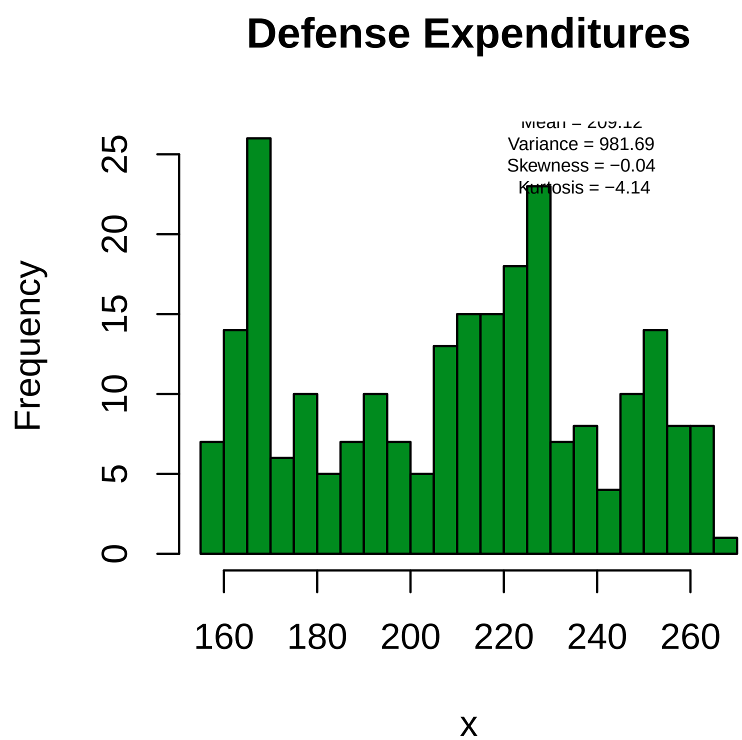
10


Test − US Federal Expenditures on Nondefense Employment
Billions 2015:Q1 Dollars
50
100
150
1960
1970
1980
1990
2000
2010
Time
Non−defense Compensation
Predicted value
95% CI

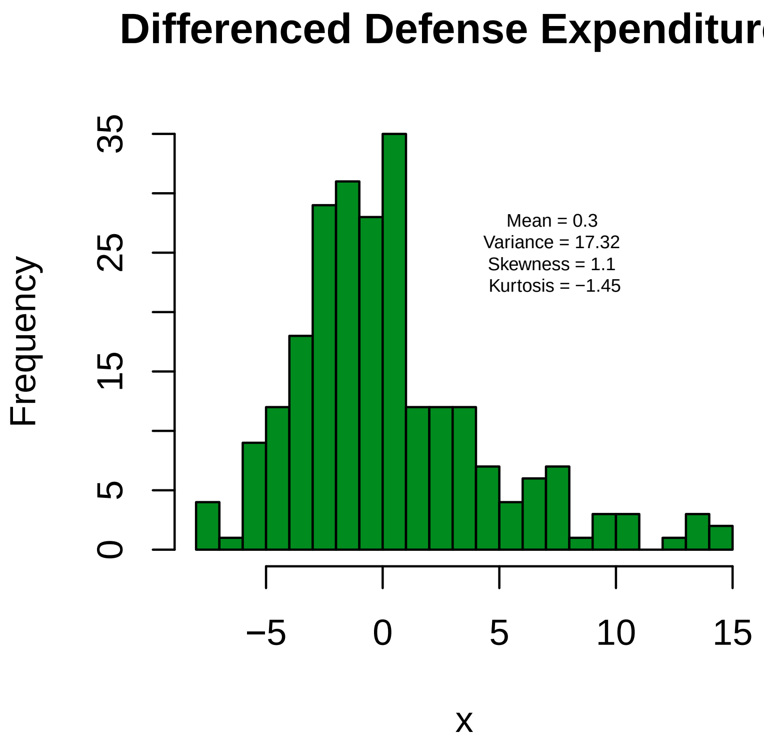
11


US Federal Expenditures on Defense and Nondefense Employment
Billions 2015:Q1 Dollars
50
100
200
1960
1970
1980
1990
2000
2010
Time
Nondefense Compensation

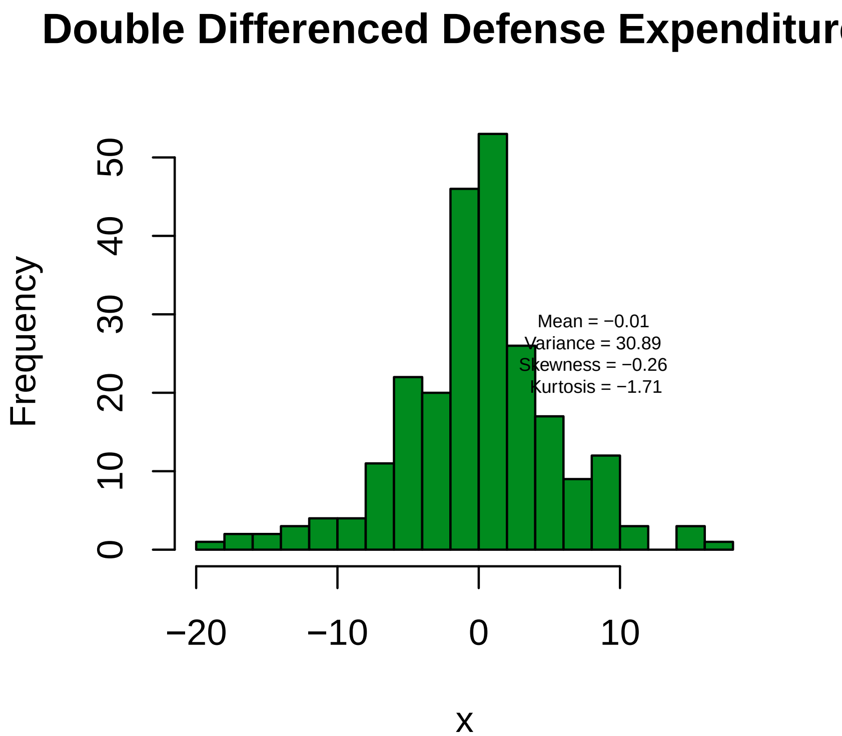
12


Defense Expenditures
Variance = 981.69
Skewness = −0.04
Kurtosis = −4.14
Frequency
0
5
10
15
20
25
160
180
200
220
240
260
x

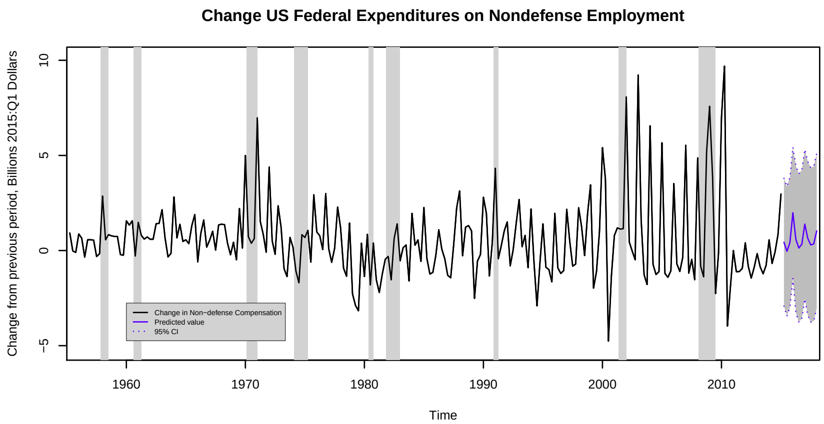
13

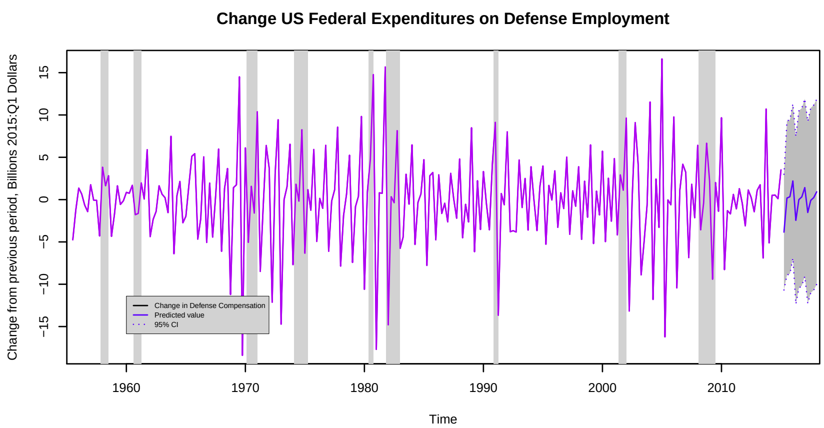

Differenced Defense Expenditures
Frequency
0
5
15
25
35
Mean = 0.3
Variance = 17.32
Skewness = 1.1
Kurtosis = −1.45
−5
0
5
10
15
x

14

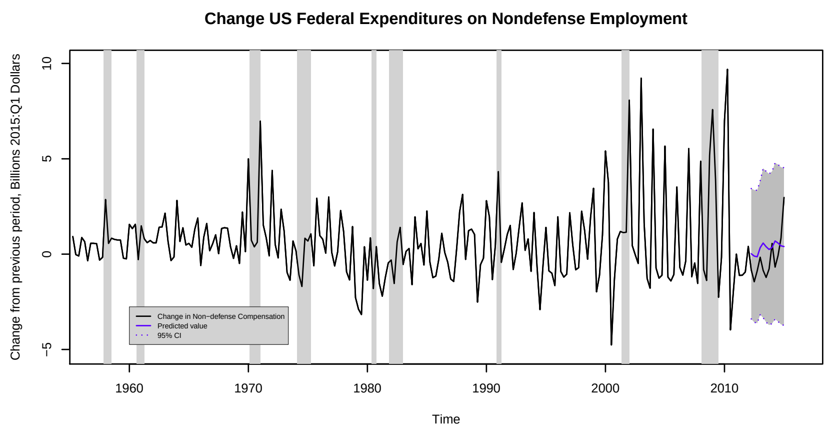

Double Differenced Defense Expenditure
Frequency
0
10
20
30
40
50
Mean = −0.01
Variance = 30.89
Skewness = −0.26
Kurtosis = −1.71
−20
−10
0
10
x

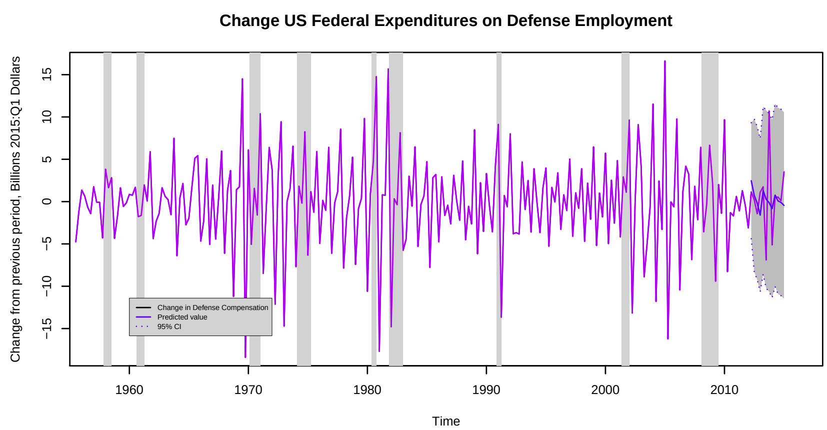
15


Change US Federal Expenditures on Nondefense Employment
Change from previous period, Billions 2015:Q1 Dollars
Time
Change in Non−defense Compensation
Predicted value
95% CI

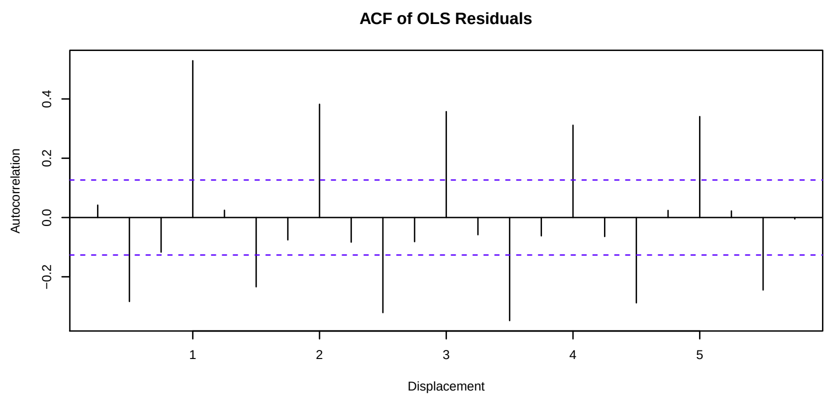

Change US Federal Expenditures on Defense Employment
Change from previous period, Billions 2015:Q1 Dollars
Time
Change in Defense Compensation
Predicted value
95% CI

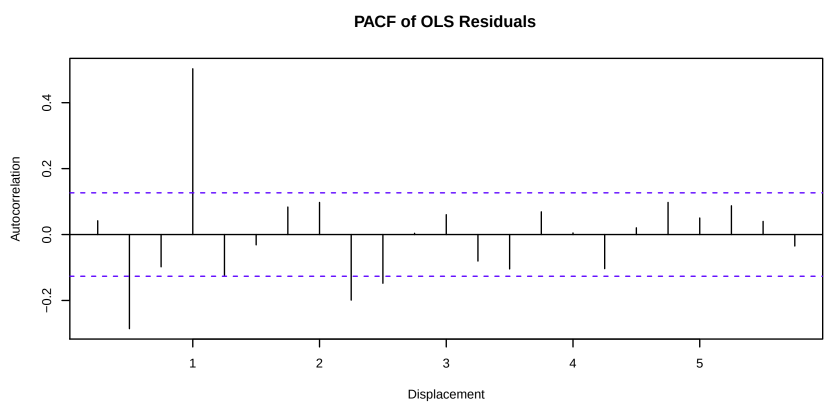
16


Change US Federal Expenditures on Nondefense Employment
Change from previous period, Billions 2015:Q1 Dollars
Time
Change in Non−defense Compensation
Predicted value
95% CI

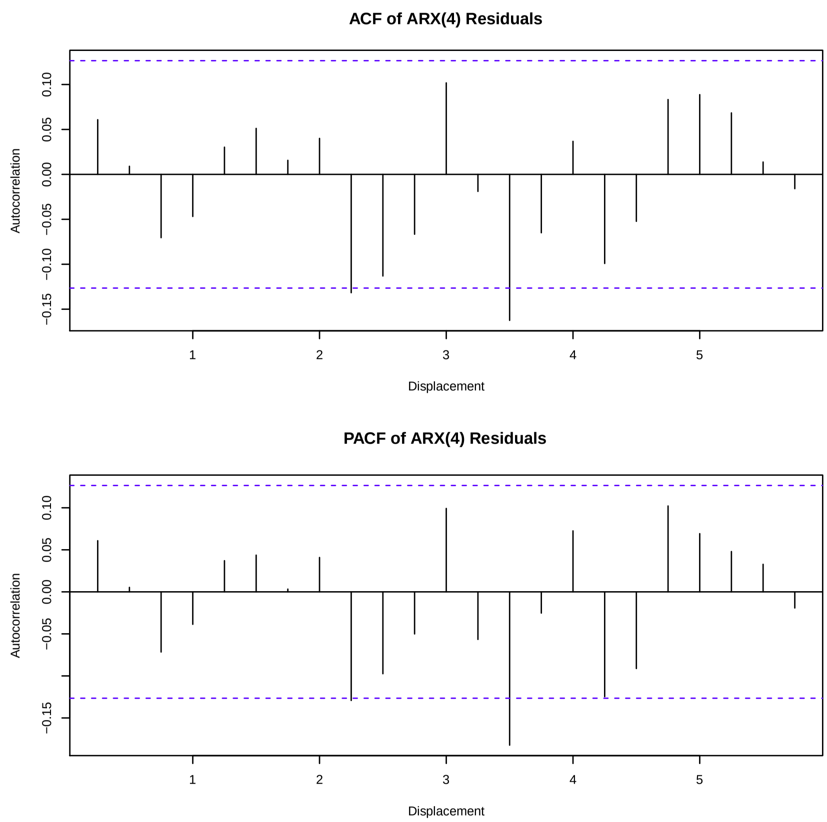

Change US Federal Expenditures on Defense Employment
Change from previous period, Billions 2015:Q1 Dollars
Time
Change in Defense Compensation
Predicted value
95% CI

17

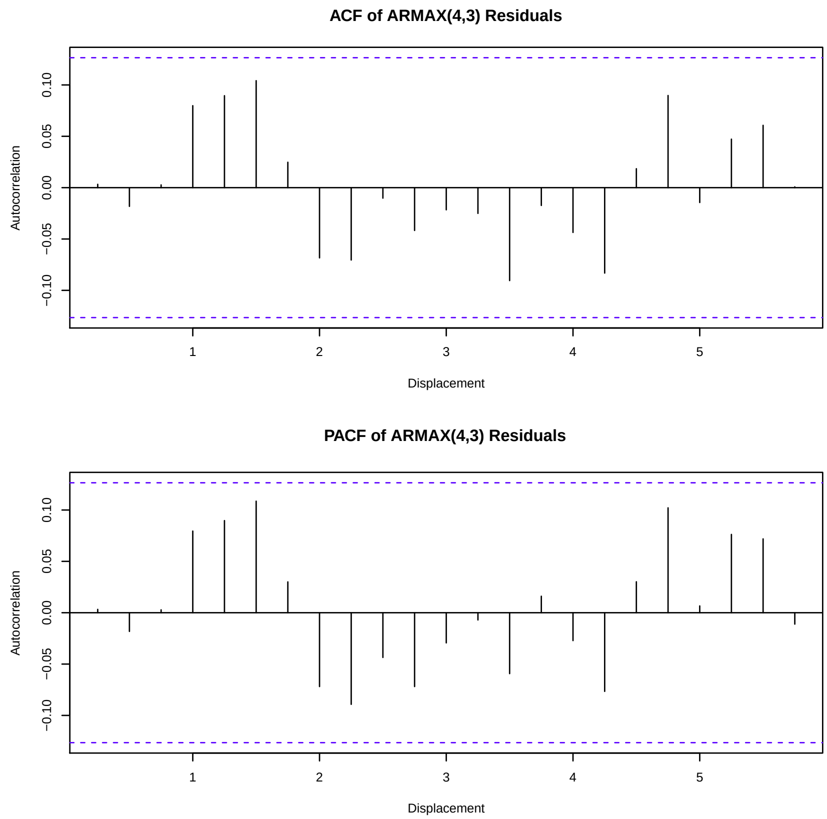

ACF of OLS Residuals
Autocorrelation
0.4
0.2
0.0
−0.2
1
2
3
4
5
Displacement


PACF of OLS Residuals
Autocorrelation
0.4
0.2
0.0
−0.2
1
2
3
4
5
Displacement

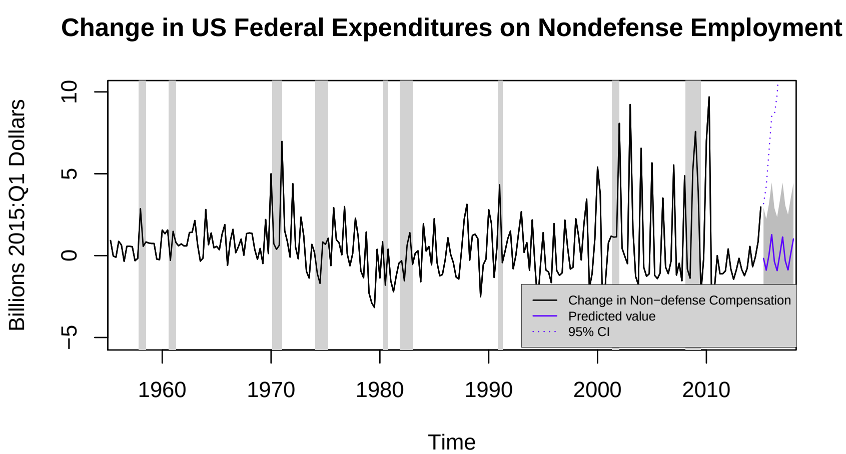
18


ACF of ARX(4) Residuals
Autocorrelation
−0.15 −0.10 −0.05 0.00 0.05 0.10
1 2 3 4 5
Displacement
PACF of ARX(4) Residuals
Autocorrelation
−0.15 −0.05 0.00 0.05 0.10
1 2 3 4 5
Displacement

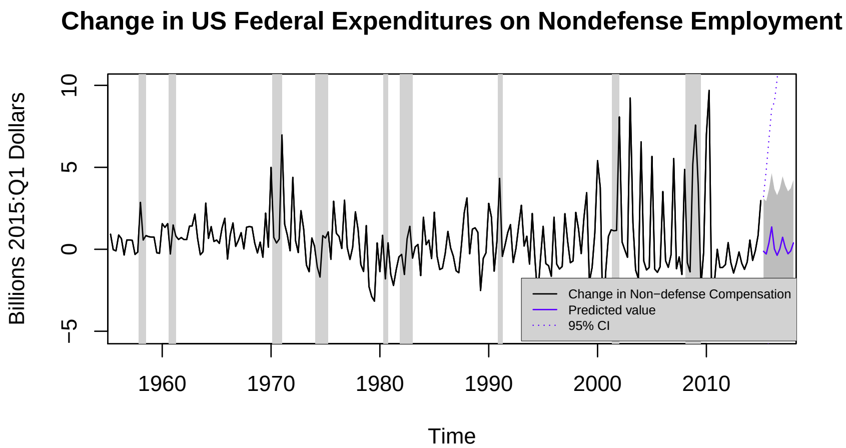
19


ACF of ARMAX(4,3) Residuals
Autocorrelation
0.10
0.05
0.00
−0.05
−0.10
1
2
3
4
5
Displacement
PACF of ARMAX(4,3) Residuals
Autocorrelation
0.10
0.05
0.00
−0.05
−0.10
1
2
3
4
5
Displacement

20

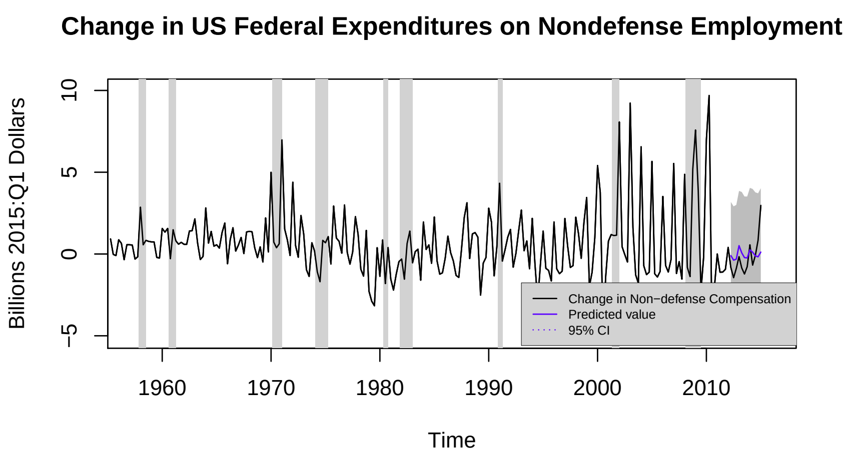

Change in US Federal Expenditures on Nondefense Employment
Billions 2015:Q1 Dollars
10
5
0
−5
1960
1970
1980
1990
2000
2010
Time
Change in Non−defense Compensation
Predicted value
95% CI

21



Change in US Federal Expenditures on Nondefense Employment
Billions 2015:Q1 Dollars
−5
0
5
10
1960
1970
1980
1990
2000
2010
Time
Change in Non−defense Compensation
Predicted value
95% CI

22



Change in US Federal Expenditures on Nondefense Employment
Billions 2015:Q1 Dollars
−5
0
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10
1960
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2010
Time
Change in Non−defense Compensation
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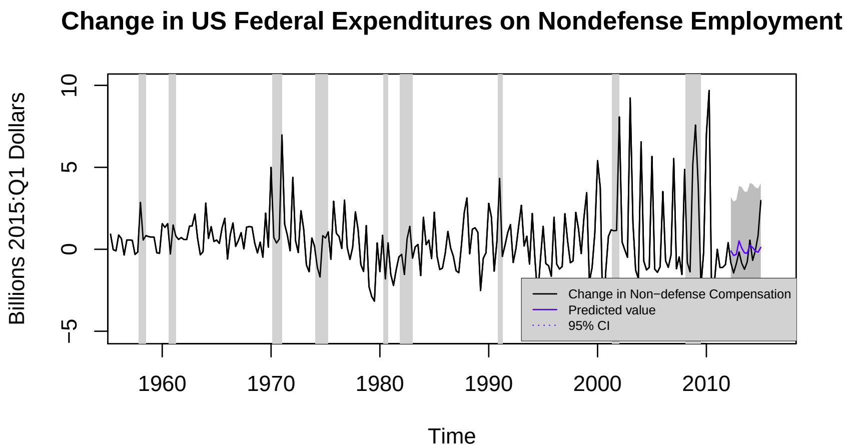
23



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6.2 Tables

Table 1: Data Summary

	"Nondefense"	"Defense"	"Rep House"	"Rep Senate"	"Rep Presidency"	"Recession"
Min	31.60203	156.9121	0	0	0	0
Mean	99.48796	209.1196	0.2708333	0.2708333	0.5625	0.1375
Max	177.1876	265.3824	1	1	1	1
Std. Dev.	36.21168	31.33188	0.4453189	0.4453189	0.4971151	0.3450941

Table 2:

	Dependent variable:		
	nondefense.d		
	(1)	(2)	(3)
recession	0.688*		
	(0.384)		
exoghouse.rep		−1.101*	−0.997*
		(0.568)	(0.573)
exogsenate.rep		0.340	0.838
		(1.198)	(1.336)
exogpres.rep		0.083	0.221
		(0.340)	(0.363)
exogcongress.rep		0.591	0.093
		(1.006)	(1.167)
exoghouse.pres.rep		1.746*	2.055*
		(0.945)	(1.102)
exogsenate.pres.rep		−1.329	−1.777
		(1.104)	(1.227)
exogrecession		0.590	1.922**
		(0.399)	(0.946)
exog.ihouse.rep ∗recession			−1.045
			(1.571)
exog.isenate.rep ∗recession			−0.256
			(1.145)
exog.ipres.rep ∗recession			−1.481
			(1.078)
exog.icongress.rep ∗recession			
exog.ihouse.pres.rep ∗recession			
exog.isenate.pres.rep ∗recession			
Constant	0.465***	0.584**	0.480*
	(0.142)	(0.256)	(0.264)
Observations	240	240	240
R^2	0.013	0.056	0.068
Adjusted R^2	0.009	0.028	0.027
Residual Std. Error	2.050 (df = 238)	2.031 (df = 232)	2.031 (df = 229)
F Statistic	3.201* (df = 1; 238)	1.971* (df = 7; 232)	1.666* (df = 10; 229)

Note: *p<0.1; **p<0.05; ***p<0.01

Table 3: VAR(4) Estimates

	Dependent variable:	
	y	
	(1)	(2)
nondefense.d.l1	0.169**	−0.208
	(0.065)	(0.133)
defense.dd.l1	0.005	−0.829***
	(0.036)	(0.073)
nondefense.d.l2	−0.128*	−0.191
	(0.067)	(0.137)
defense.dd.l2	0.010	−0.699***
	(0.041)	(0.084)
nondefense.d.l3	−0.070	−0.112
	(0.067)	(0.136)
defense.dd.l3	0.003	−0.595***
	(0.041)	(0.083)
nondefense.d.l4	0.480***	0.047
	(0.065)	(0.133)
defense.dd.l4	0.060*	0.017
	(0.033)	(0.066)
const	0.313**	0.257
	(0.129)	(0.262)
Observations	235	235
R^2	0.344	0.625
Adjusted R^2	0.321	0.611
Residual Std. Error (df = 226)	1.714	3.488
F Statistic (df = 8; 226)	14.816***	47.036***
Note:	*p<0.1; **p<0.05; ***p<0.01	

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