**Lab Write-up Macro**

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**Econometrics**

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**Intro**

Is it possible to predict the future state of the US economy based off past states using autoregressions and distributed lag models? This paper attempts to show which model is best for forecasting US Real GDP growth rate.

**Data and Methods**

The data used is US macroeconomic data from 1947 through 2009, obtained from the Federal Reserve Economic Database (FRED), provided by the US Federal Reserve Bank of St. Louis. Table 1 defines the variables used and Table 2 contains summary statistics. Each observation is of a quarter, and the dollar units are chain-adjusted for 2005 dollars.

The GDP Growth Rate was regressed on the independent variables using ordinary least squares regression with heteroskedastic-consistent standard errors.

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| Table 1. Variables Used | |
| Variable | **Description** |
| Real GDP | Quarterly values of the US Real GDP chain-adjusted for inflation in 2005 Dollars |
| TBillRate | Quarterly average values of the rate on 3-month Treasury Bill, in percentage points at an annual rate |
| ΔR | Quarterly Difference in TBillRate |
| Yt | Logarithm of Real GDP |
| ΔYt | The Quarterly Change in Real GDP |
| Growth Rate | THE Quarterly GDP Growth Rate |
| Annual Growth Rate | Annual Percent Growth Rate of Real GDP |
| Year | The Year the of the observation |
| Quarter | The Quarter of the observation |
| Period | The period of the observation since the beginning of the data set |

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| Table 2. Summary Statistics | | | | | |
| Variable | **Obs** | **Mean** | **Std. Dev.** | **Min** | **Max** |
| Year | 252 | 1978 | 18.2204 | 1947 | 2009 |
| Quarter | 252 | 2.5 | 1.12025 | 1 | 4 |
| RealGDP | 252 | 6291.05 | 3510.47 | 1768.03 | 13363.4 |
| TBillRate | 252 | 4.59062 | 2.92586 | .056666 | 15.0533 |
| Period | 252 | 73.5 | 72.8903 | -52 | 199 |
| Yt | 252 | 8.57802 | .600606 | 7.477623 | 9.50028 |
| ΔYt | 210 | 3.80561 | .935290 | -.203340 | 5.37254 |
| Growth Rate | 251 | .007864 | .009908 | -.027824 | .038849 |
| Annual Growth Rate | 251 | 3.14569 | 3.96339 | -11.1299 | 15.5397 |
| ΔR | 251 | -.001288 | .708624 | -3.73666 | 4.45999 |

**Results**

The mean growth rate was 3.145 percent with a standard deviation of 3.963 over the period studied. Table 3 displays the first 4 autocorrelations of the annualized percent growth. They are all significant at more than 99.99% confidence. The autocorrelations have no units.

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| Table 3. First 4 Autocorrelations of Change in GDP | | | | |
| LAG | **AC** | **PAC** | **Q** | **Prob>Q** |
| 1 | 0.3678 | 0.3681 | 34.357 | 0.0000 |
| 2 | 0.2116 | 0.0890 | 45.779 | 0.0000 |
| 3 | -0.0000 | -0.1238 | 45.779 | 0.0000 |
| 4 | -0.0883 | -0.0897 | 47.785 | 0.0000 |

Autoregressions were computed to predict growth rate. Table 4 displays the regression results from AR(1/4) models, and an ADL(1/4) model including lags of interest rate changes. In the AR models, only the first lag of the growth rate is statistically significant at 95%, with a 95% confidence interval of (0.162, 0.488). That is a large confidence interval for the estimate, suggesting a high variation in growth rates. According the AR(1) model, if the lagged growth rate increases by 100%, then the present growth rate would increase by 36.8%. The AR(1) model explains 13.2 percent of the variance.

In the ADL(1/4) model (5), the first lag on growth rate is highly significant and the second lag is significant at 90% confidence. They predict that the growth rate of the current period would be 32.5% plus 16.1% of the growth rates in the last two periods, respectively. The first lag on the change of interest rate is significant at 90% confidence, the second lag is significant at 99.9% confidence, and the fourth lag is significant at 95% confidence. It predicts that current growth rate will be 32.5% of the previous growth rate plus 16.1% of the growth rate two periods ago, minus very small, but significant values dependent on previous interest rates. All the constants are highly significant. The Granger causality F-statistic for model 5 is 7.350, suggesting the model is significant.

It is necessary to pick how many lags should be present in the models with BIC and AIC. Model 5 has the lowest BIC and model 4 has the lowest AIC. For AR(1), a Dickey-Fuller test for a Unit Root was conducted (table 5), resulting in a MacKinnon approximate p-value for Z(t) = 1.0000, allowing us to reject the unit root hypothesis with high confidence. It is also necessary to test for structural breakpoints in the models with a Quandt likelihood ratio (QLR) statistic with 15% trimming. The QLR F-statistic for the AR(1) model is insignificant at 95% confidence. The QLR F-statistic for a break in the ADL(1/4) model with lags on interest rate changes is 6.695, and is significant at 99% confidence. This suggests a breakpoint in 1961 for the ADL(1/4) model.

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| Table 5. Dickey-Fuller Test for Unit Root | | | | |
|  | **Test Statistic** | **1% Critical Value** | **5% Critical Value** | **10% Critical Value** |
| Z(t) | 3.899 | -3.460 | -2.880 | -2.570 |

In addition to the previous models, a “Naïve” model was constructed according to the following equation.

ΔYt+1/t = (ΔYt+ +ΔYt-1 +ΔYt-2+ΔYt-3)/4

Pseudo Out-Of-Sample forecasts for the Naïve, AR(1), and ADL(1/4) models are shown in figures 1, 2, and 3 respectively in the back.

The RSMFE for the forecasts are as follows in table 6.

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| Table 6. RSMFE for Pseudo Out-Of-Sample Forecasts | | |
| Model | **Mean Error** | **Std. Dev. Error** |
| AR(1) | .00149 | .00578 |
| ADL(1/4) | .00159 | .00570 |
| Naïve | .00172 | .00619 |

The AR(1) model has the lowest mean error, but the ADL(1/4) model has lowest variance in its standard error. The Naïve model has a worse RSMFE and higher variance in its error term than the other models. This would suggest that the AR(1) and ADL(1/4) models are better than the Naïve model.

**Conclusion**

An ADL(1/4) model with lags of changes in interest rate has proven to be the best model. It explains the most of the variance in the data, although it has a slightly higher RSMFE than the AR(1) model. It also has the lowest variance in its error term. The Naïve model is worse than both the AR(1) model and the ADL(1/4) model. More than one lags in the AR models are not significant, although more lags of changes in interest rate were. The ADL(1/4) model with lags of interest rate changes is shown to be the best for forecasting.

**Figures**

Figure 1.



Figure 2



Figure 3.

