An Explanatory Model of United States Inflation

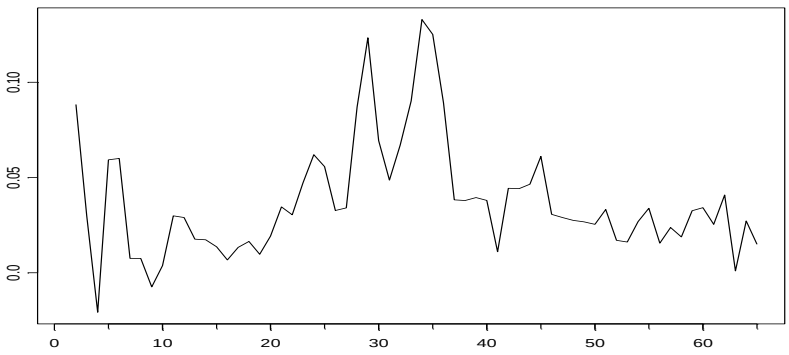
Manuel G. Russon, Ph.D, CFA
Associate Professor, Dept. Computer Information and Decision Sciences
St. John's University
Jamaica, NY 11439
718-990-7363
russonm@stjohns.edu

Kaushal Shah

Introduction

Inflation is defined as a broadbased increase in the general price level of an economy. Fig. 1, displays a time series chart of year over year US inflation since 1946. Other nations have similar experiences with inflation.

Fig. 1 Seq.Plot: Inflation



Inflation has been a topic of interest, investigation, theorizing and debate by social scientists in general, and economists in particular for decades. Social scientists debate the effects of inflation on human organization while economists develop models to understand the causes and dynamics of the phenomenon. Economists have long debated the causes of these bouts of inflation. The "Chicago School of Economic Thought" advances the notion that inflation "…is everywhere and anywhere a monetary phenomenon", i.e. that increases in the money supply will, after some lag, increase the price level. Common thinking is that the lag is long and variable. Other schools of thought hold that inflation is caused by stresses on labor or industrial capacity, the consequence of supply shocks and economic dislocations, or other.

This research advances a model which synthesizes the results of decades of research. Graphical techniques, descriptive statistics and multiple regression are used to assess and model the effect of various macro-economic variables on the direction and

magnitude of inflation. Based upon the conclusions of the statistical analysis, recommendations for public economic policy are advanced.

Methodology

The functional specification is given in Eqn. 1, below:

$$\text{Eqn: 1} \quad \text{Inflation} = f(\%\Delta\text{MoneySupply}^{+}, \text{Unemployment Rate}^{-}, \text{Capacity Utilization}^{+})$$

A. The Quantity Theory of Money. The Quantity Theory of Money is advanced by the Monetary School of Economic Thought, and is summarized in Eqn. 2, below:

$$\text{Eqn.2:} \quad MV=PQ=GDP$$

It holds that the money supply, M, multiplied times Velocity of Money, V, is equal to Price Level, P, times the level of real output. The equation is actually a definitional tautology. The mathematics always works out. If GDP and M are known, then V can be solved for. Hence the equation has no policy prescriptions. On the other hand, if V is taken as a long run average and mean reverting constant, then the equation does have policy prescriptions. Thus, if the money supply increases, then short term velocity will, by definition, initially decrease, as GDP is short term constant. However, as the money supply works its way through the economy, then assuming a constant rate of real output, Q, and constant Q, those changes in the money supply will impact the price level. Inflation will have set in.

In percent differences, the relationship can be expressed as in Eqn. 3, below:

$$\text{Eqn. 3:} \quad \%\Delta M+\%\Delta V=\%\Delta P+\%\Delta Q=\%\Delta GDP$$

B. The Phillips Curve. In 1960, British economist A.W. Phillips advanced the notion of a Phillips Curve. Using United Kingdom data from 1800 to 1958, he observed an inverse relationship between the rate of unemployment and the rate of wage inflation. The same observation has been extended to price inflation. His conclusion was that as the Unemployment rate decreases, businesses will be able to raise prices and as this happens, it will manifest itself in broad based inflation.

C. Capacity Utilization. A similar argument could be made for Capacity Utilization. Capacity Utilization is the percent of manufacturing capacity currently employed. In a sense, 1.0-Capacity Utilization Rate is the unemployment rate of manufacturing. As capacity utilization increases, and unit manufacturing costs increase due to diseconomies of scale and decreasing marginal productivity of inputs, and businesses will raise output prices. If this occurs in a broad based way, it will present itself in the macro economy as inflation.

Historical data for the Consumer Price Index, Unemployment Rate, and the M2 measure of the Money Supply and Capacity Utilization with one year granularity are obtained from the Federal Reserve Bank of St. Louis website. While data for Unemployment and Money Supply are available since 1920, data for Capacity Utilization is available only since 1967. Hence, the data set will be comprised of data since 1967.

Year over year Inflation and percent changes in the M2 are computed as

Eqn. 4: $infl=(cpi-cpi_{t-1})/cpi_{t-1}$ where cpi is the consumer price index.

Eqn. 5: $\%\Delta m2 = (m2-m2_{t-1})/m2_{t-1}$ where m 2 is the money supply.

Graphical techniques, correlation and multiple regression analysis will be used to model the year over year inflation rate as a function of Unemployment Rate, $\%\Delta m2$ and Capacity Utilization. Lag distributions of these independent variables will be used to assess lagged effects of each on the inflation rate. The statistical analysis will be undertaken using S-Plus.

Results

Table 1, below, displays descriptive statistics for each variable.

Table 1. Descriptive Statistics

	Mean	stdev	skew	kurt
infl	0.037	0.030	1.315	2.086
%∆ms2	0.069	0.031	0.220	-0.217
capu	80.88	4.260	-0.428	-0.025
unemp	5.706	1.583	0.783	1.134

Histograms of each variable appear in Figs. 2-4, below. All are generally normally distributed. Time series charts of each variable appear in Figs. 5-8, below. Notice the cyclical nature of the various time series variables.

Table 2, below, displays the correlation matrix for inflation and the various independent variables. Changes in the money supply and capacity utilization have anticipated positive correlations. The unemployment rate, which was hypothesized to have a negative correlation coefficient, has a positive correlation coefficient. This warrants further investigation. The correlation between unemployment and capacity utilization of -.692 raises a possibility of mulitcollinearity.

Table 2 Correlation Matrix

	infla	%∆ms2	unemp	capu
infla	1.000	0.132	0.090	0.246
%∆ms2	0.132	1.000	0.132	-0.078
u	0.090	0.132	1.000	-0.692
capu	0.246	-0.078	-0.692	1.000

Macroeconomic dynamics are subject to leads and lags. To investigate the possibility that inflation is affected by previous values of independent variables, Table 3, below, is presented, which displays correlations between inflation and lead/lags for the independent variables. Significantly larger correlations appear for lagged values of changes in money supply and capacity utilization. In contrast, the correlation for unemployment and inflation is positive and even higher for leading values of the unemployment rate.

Table 3 Lead/Lag Correlations with Inflation

lag	%∆ms2	unemp	capu
-6	0.199	0.315	-0.052
-5	0.196	0.411	-0.025
-4	0.199	0.561	-0.001
-3	0.333	0.644	-0.126
-2	0.470	0.397	-0.212
-1	0.357	0.191	-0.109
0	0.104	0.137	0.246
1	0.263	0.199	0.481
2	0.457	0.283	0.407
3	0.541	0.258	0.093
4	0.452	0.140	-0.013
5	0.318	0.044	0.114
6	0.337	0.001	0.308

Scatter plots of Inflation with each independent variable with the lag period which coincides with the highest correlation appear in Figs. 10-12, below. Fig. 10 displays a scatter plot of I vs. %∆ms2 lagged 3 years. Consistent with its correlation of .541, the scatter plot displays a positive moderate relationship with no outliers. A hint of heteroscedasticity is evident. Fig. 11 displays a scatter plot of Inflation vs. CapacityUtilization lagged 1 year. Consistent with its correlation of .481, the scatter plot has a positive moderate relationship, also with no outliers. The scatter plot does show a hint of a nonlinear relationship, especially at low levels of Capacity Utilization. A scatterplot of Inflation vs. Unemployment appear in Fig. 12. The slope of the scatter plot agrees with the positive correlation, but the relationship is unexpected. The hypothesis is for a negative relationship between Unemployment and Inflation. Indeed the entire vector of lag correlations between Inflation and Unemployment is positive.

Except for the correlation and scatter plot of I vs. Unemployment, the correlations and scatter plots generally provide tentative evidence in support of the hypotheses.

Stepwise Linear Regression is performed to model the effect of the independent variables on inflation with entering variables allowed at the 20% level of significance and variables removed if they do not pass the 25% level of significance once they have been entered. The results are presented in Table 4, below:

Table 4 Regression Results

$$I = a + b1*\%\Delta ms2_{t-2} + b2*\%\Delta m2_{t-3} + b3*\%\Delta m2_{t-4} + b4*capu_{t-1} + e$$

	Value	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.6034	0.0869	-5.9685	0.0000
chgms2	0.2623	0.1038	2.5261	0.0161
chgms3	0.2108	0.1193	1.7670	0.0857
chgms4	0.2507	0.1058	2.3703	0.0233
capu1	.0059	0.0010	6.1368	0.0000

R-Square=0.713 F=16.47 F-sig=.000 RMSE=0.017 df=36 DW=1.3

The explanatory power of the model is moderately high at 73.3 %. Therefore 73.3% o f the variation in year over year inflation can be explained by or attributed to variation in the lag structure of the three independent variables. The F-statistic and the associated F-sig indicate the model is significant at less than 1% level of significance. The Durbin-Watson statistic is 1.3 indicating a problem with serial correlation.

The individual coefficients have their expected signs, are all statistically significant at the 5% level of significance or better and all have their conventional interpretation. Noteworthy is that the percent change in the money supply has an impact lag of 2 years and significant effects distributed from lag period 2 to lag period 4. Also, capacity utilization enters the model and is significant with a 1 year lag. The unemployment rate did not enter the stepwise procedure at even the 20% level of significance. This does not add evidence in and hence, is problematic for support

A histogram of the residuals appears in Fig. 13, below. The residuals, which should be normally distributed, display a slight skew to the left. A scatter plot of the actual and predicted values appears in Fig. 14. The data points suggest a slight nonlinear positive relationship between the actual and predicted values, albeit with no outliers. A time series plot of the actual and predicted values appears in Fig. 15. The actual and predicted values track each other nicely, giving credence to the model. Fig. 16 displays a sequence plot of the residuals giving graphical evidence to the conclusion that serial correlation is present.

The results provide evidence in support of the monetarist quantity theory of money and for the notion of high capacity utilization having the effect of increasing inflation. No evidence is advanced supporting the Phillips Curve.

The results are subject to concerns relating to nonlinear effects on the inflation rate of changes in the independent variables. Correcting for these nonlinear effects could have marginal changes on the coefficients and explanatory power. However, even after correcting, the general conclusions of this research will probably be unchanged.

IV. Conclusions

The research reinforces, but also synthesizes, the conclusions of previous research and has significant implications for policy. Large increases in the money supply engenders inflation after two years. Sixty percent of that increase reflects itself, ultimately, in inflation. A stable monetary policy with slow growth in the money supply adds to a stable price level. With regard to capacity utilization, policy makers should alter tax policy to increase investment in manufacturing capacity so as to mitigate price increase pressures. The results indicate that the level of unemployment does not affect the level of inflation. Hence policy makers need not worry that low levels of unemployment will overheat the economy and result in higher inflation.

Further research might correct for the nonlinear relationship in capacity utilization on inflation. As noted, this might have the effect of altering coefficients and t-statistics making insignificant coefficients significant and perhaps significant coefficients insignificant. Additionally, further research might include supply shocks, as represented by commodity price changes, on inflation as well as the effect of the change in real output and the effect of dislocations associated with war efforts. Lastly, further research might advance a disaggregated model to separate analyses for various components such as housing or services.

References

Milton Friedman and Anna Schwartz , "A Monetary History of the United States". National Bureau of Economic Research. ISBN 0-691-00354-8. 1963

A.W. Phillips, "The Relation Between Unemployment and Rate of Change of Money Wages in the United Kingdom, 1861-1957," Economica, November 1958.

Fig. 2 Hist: 12Mth Inflation

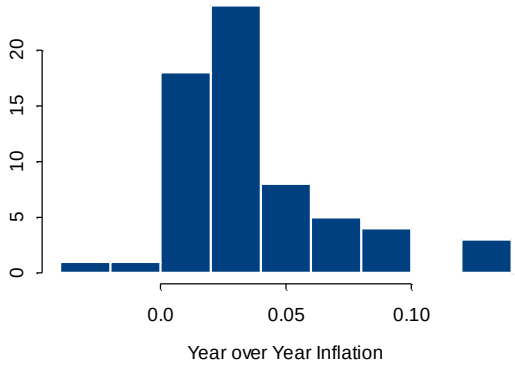


Fig. 3 Hist: Capacity Utilization

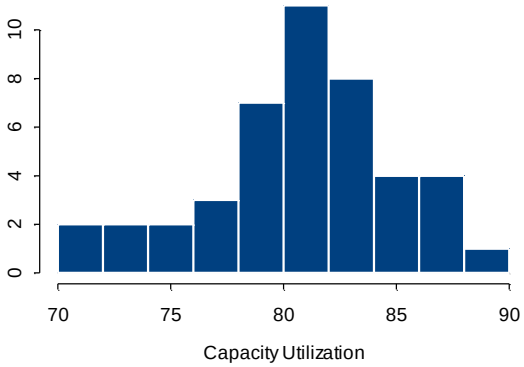


Fig. 4 Hist: Unemployment

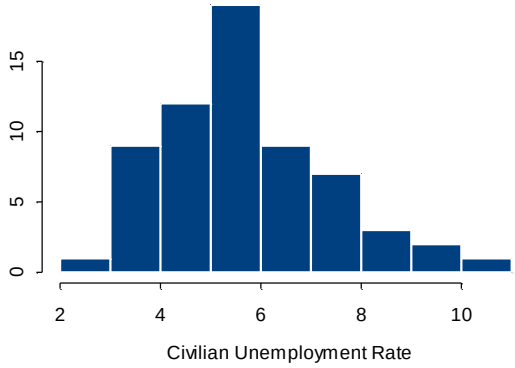


Fig. 5 Hist: 12Mth Growth M1

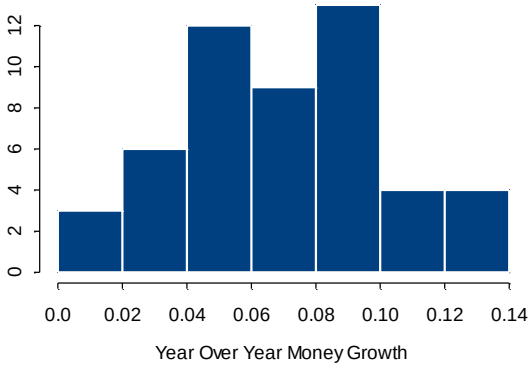


Fig. 6 Seq.Plot: Inflation

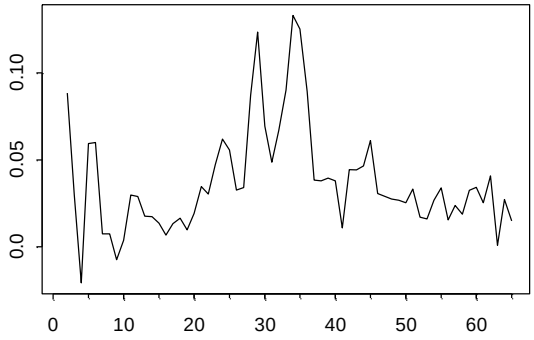


Fig. 7 Seq.Plot: Capacity Utilization

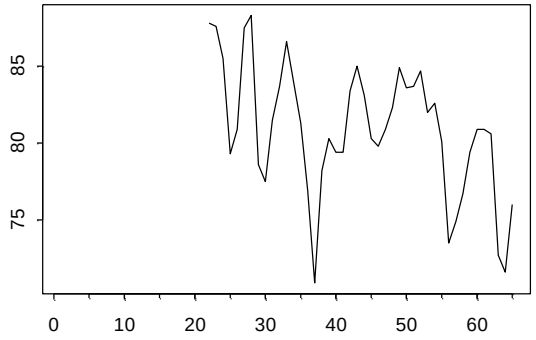


Fig. 8 Seq.Plot: Unemployment

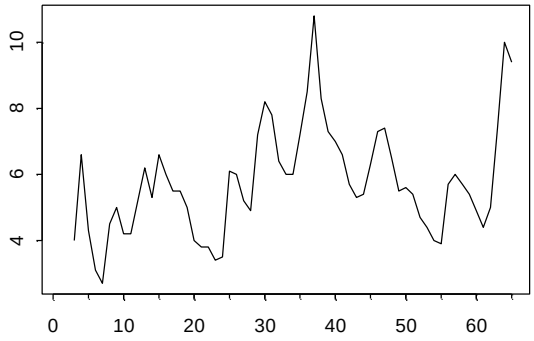


Fig. 9 Seq.Plot: yoy M2 Growth

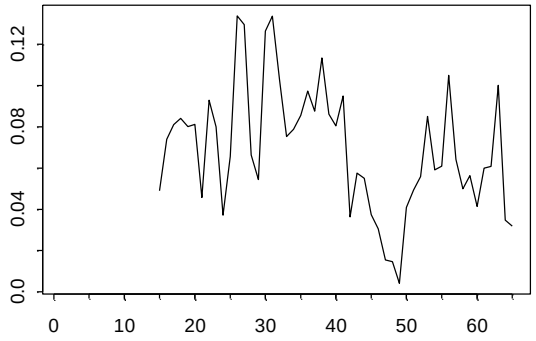


Fig. 10 Inflation v. M2 Growth

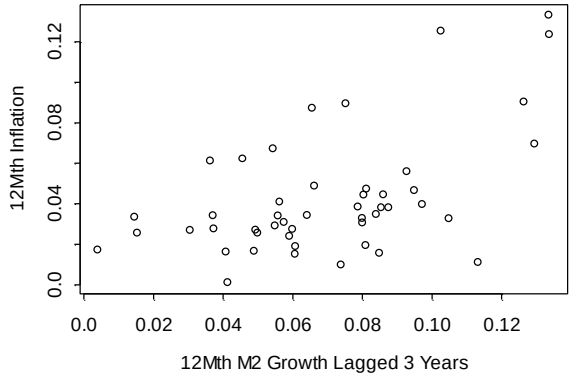


Fig. 11 Inflation v. Capacity Utiliztion

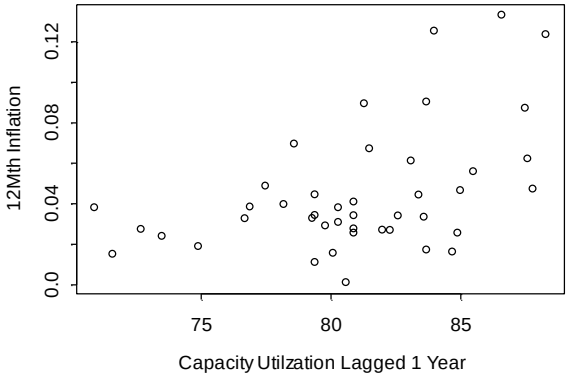


Fig. 12 Inflation v. U

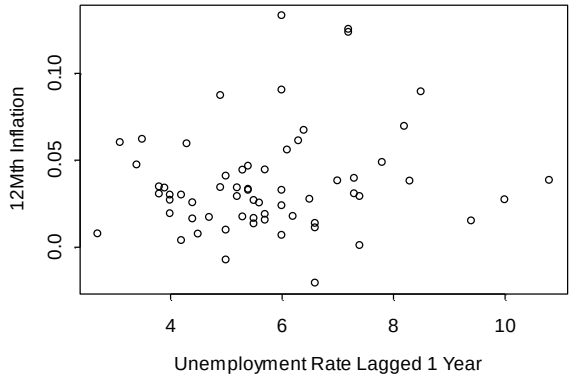


Fig. 13 Hist: Residuals

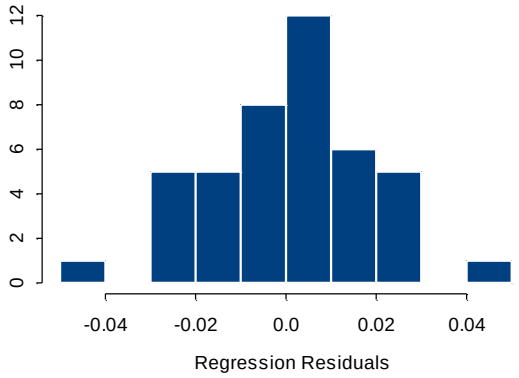


Fig. 14 Act v. Pred 12 Month Inflation

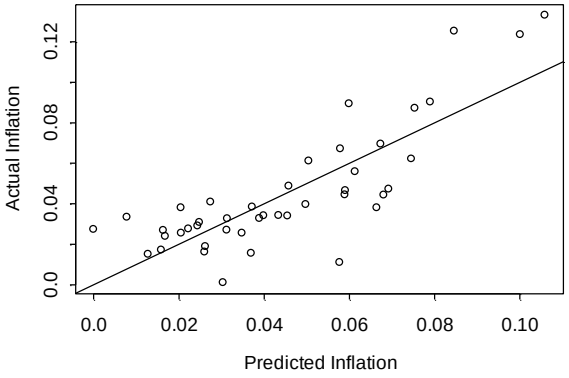


Fig. 15 Seq. Plot: Act v. Pred 12 Mth Inflation

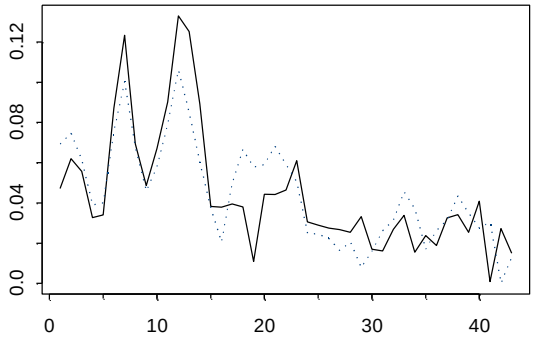


Fig. 16 Seq. Plot: Residuals