Money Growth and Inflation in the United States

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Abstract

In this paper, I examine whether the current neglect of money growth in formulating monetary policy is consistent with the data. In particular, I examine whether money growth helps to predict inflation. The evidence indicates that money growth clearly helps to predict nominal income and is more informative than any other single variable about future inflation.

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1 Introduction

In this paper, I examine whether the current neglect of monetary aggregates in formulating monetary policy is consistent with the data. Monetary aggregates play little or no role in the formulation of monetary policy in the United States. Is this neglect justified? Inflation in the United States has fallen from 8 to 9 percent per year from 1979 to 1981 to roughly 2 percent in 2000 as measured by the GDP deflator. If it is hard to argue with success, then whether justified or not, perhaps the neglect is low cost if not justified. Some recent papers have examined this issue with differing conclusions [Friedman and Kuttner 1992; Estrella and Mishkin 1997; Thoma and Gray 1998; Den Haan 2000]. Partly related papers have examined the relationship between monetary aggregates and nominal and real income [Feldstein and Stock 1996; Swanson 1998]. In this paper, I examine a facet of this question: Is a monetary aggregate a useful indicator of United States inflation? If so, then completely ignoring the behavior of monetary aggregates may be an unwise way to conduct monetary policy.

This narrow focus means that I will not examine other possible uses of monetary aggregates in formulating and implementing monetary policy. I take it for granted that values of monetary aggregates are nonsensical goals for monetary policy. Inflation and possibly real income growth are tenable goal variables; monetary aggregates are not. Monetary aggregates may be useful intermediate targets for achieving these goals, but I do not examine the implications of using monetary aggregates as intermediate targets. Monetary aggregates currently are used in Switzerland and have been used by other countries [Gomme 1998]. A precondition for using monetary aggregates as an intermediate target for inflation is the aggregate's usefulness for predicting inflation or real income growth, so the analysis in this paper does have implications for the likely usefulness of money as an intermediate target.

The analysis in this paper is limited to inflation and generally ignores real income growth. This limitation is due to a number of factors, but perhaps the most telling is that recessions are hard to predict by any set of variables or methods. The desirability of using a monetary aggregate as in McCallum's proposed rule for monetary policy [McCallum 1988] or an interest rate as in Taylor's proposed rule [Taylor 1993; , also depends on the closeness of the relationship between the monetary aggregates and the goals. Hence, this seemingly narrow focus is not really all that narrow. Money's usefulness as an indicator of inflation is a necessary condition for other possible uses of money in conducting monetary policy.

2 Money and Prices

It is conventional wisdom that "inflation is always and everywhere a monetary phenomena," an epigram due to Friedman that has been repeated by him and others many times [Friedman 1992]. There seems to be widespread agreement about this observation in the theoretical literature, and the empirical relevance of the observation is taken for granted by many. Figure 1 uses quarterly data on money, real income and the price level for 1953 though 1997 to show why money's empirical relevance is taken for granted.[1] In Figure 1, higher prices are associated with higher quantities of money relative to income, both in terms of the overall trend and changes in trend. There is one startling deviation: money per unit of output fell from 1992 to 1997 but the price level did not. This graph suggests that the relationship between money per unit of output and the price level since 1992 is looser than for the previous

[1] The sources of the data are discussed in the Data Appendix.

thirty-five years. This deviation in the 1990s is larger in absolute and relative terms than earlier deviations. There is some suggestion that the deviation was a permanent downward shift in money per unit of output. The slope of the line for the price level and money per unit of output is most dramatically different for 1992 to 1995 and is more nearly the same for 1995 to 1997.

While it is natural to focus on this recent period, the current period is not as atypical as examination of Figure 1 by itself would suggest. Figure 2 shows the relationship between money and prices in the United States for the twentieth century. The deviation of money per unit of output from the price level in the 1990s still is visible but this deviation is not as large as some prior deviations. Just before the Treasury-Federal Reserve Accord in 1953, for example, there was a substantial increase in money relative to income and then a decrease. In the earlier years of the twentieth century, money relative to income increased more than prices until the 1930s. The graph shows money relative to income and prices as a percent of the period average. As a result, changes in the mean can affect the size of the deviations. Still, the recent deviations are relatively large and hardly are comforting about the usefulness of the relationship between money growth and inflation for predicting inflation.

The figures above are abundantly clear about two things: money is indeed related to inflation when allowance is made for the behavior of real income; the relationship is not an exact linear one. This message is similar to that delivered by graphs presented by Milton Friedman in many places for some years, for example [Friedman 1992].

The quantity theory is a basis for thinking about these graphs. The quantity theory is

$$MV = Py, \tag{1}$$

where M is the nominal quantity of money, V is income velocity, P is the price level and y is real income. The figures show the relationship between money per unit of output, M/y, and P, which would be identical lines if velocity were constant. Hence, one interpretation of the figures is that changes in velocity are important.

These figures are not the only possible way of summarizing the relationship between money and the price level. The relationship between money and nominal income ($Y = Py$) is another way of summarizing the relationship between money and inflation that also allows for the growth of real income. Yet another way of summarizing equation (1) is in terms of the relationship between money growth and inflation directly. The relationship between money growth and inflation is rough over shorter time periods and closer over longer time periods [Dwyer and Hafer 1988; McCandless and Weber 1995]. Dwyer and Hafer [1999] use the growth of money per unit of output and inflation to illustrate the relationship between money growth and inflation. In this paper, I use money growth, nominal income and inflation to examine the relationship between money and the price level.

Table 1 shows simple correlations of money growth, nominal and real income growth and inflation for data averaged over different time periods. The time periods spanned by the changes of the variables used in the correlations range from quarters five years. The quarterly correlations are correlations of quarterly growth rates of nominal GDP, real GDP and the GDP price index with money growth. The correlations for one or more years are correlations of growth rates of annual average data for the same variables for the number of years indicated.[2] Several things are apparent in the table.

First, the quarterly correlations are quite low. The correlation of quarterly money growth with inflation is 0.223, which is the same as the correlation of quarterly money growth with real income growth. The correlation of money growth with nominal income growth is 0.346, which is higher than the correlation with inflation although not spectacularly so. Figure 3 indicates why these correlations appear as they do. The plots of quarterly money growth and nominal income are broadly similar, while quarterly inflation is much smoother than either money growth or nominal income. Money growth and inflation only agree in terms of relatively long-term movements.

Second, the correlation of money growth with inflation changes systematically as the data are averaged over longer periods. Averaging over longer periods has little effect on the correlation of money growth with nominal income growth. On the other hand, averaging over longer periods increases the correlation of money growth with inflation and decreases the correlation of money growth with real income growth.

Figure 4 shows why the time period over which nominal income growth is calculated makes relatively little difference. Figure 4 shows nominal income growth and money growth averaged over intervals of one to five years. The averaging tends to increase the smoothness of both series similarly. It is apparent that the averaging smooths out many wiggles in both series, some of which are idiosyncratic and some of which are common.

Figure 5 shows why the averaging matters for inflation. The averaging has relatively less

[2] Rather than arbitrarily select periods over which to compute non-overlapping intervals for the longer changes, I use observations for all of the years. This means that the variables have induced serial correlation, which would be problematic for standard tests of zero correlation but is not for examining how a non-zero correlation changes as the averaging interval increases. The correlations, of course, are based on fewer independent observations than the number of observations used in the correlations.

of an effect on the behavior of inflation than on money growth. Inflation is smooth even on an annual basis (actually even on a quarterly basis), but money growth is substantially smoother with changes over four or five years than over just one year.

There are various ways of interpreting these figures, but it is hard to quarrel with the observation that money growth and inflation are positively correlated and this correlation is greater over longer periods of time. Still, is this correlation useful for formulating monetary policy?

I assume that an association between monetary growth and inflation is a useful *indicator* for formulating monetary policy if money growth is helpful for predicting inflation. Is it?

3 A Vector Autoregression

In order to estimate whether money growth is helpful for predicting inflation, it is necessary to have an empirical model of the behavior of the economy rather than just figures and simple correlations. It would require substantially more knowledge than is currently available to specify a structural econometric model of the economy. Instead, I estimate a small Vector Autoregression (VAR) using quarterly data from 1953 to 1997 for four variables: the logarithm of nominal income; the logarithm of the price level; the interest rate on 3-month Treasury bills; and the logarithm of the money stock measured by M2.

The Johansen test for cointegration among the four series indicates that they are not cointegrated. Table 2 provides the test statistics. The test statistics are consistent with the null hypothesis of there being no cointegrating vector between these variables for 1953 through 1997. Given the data in Figure 1, this is not entirely surprising. The divergence after 1991 of the price level and money relative to real income suggests that these series are not likely to be cointegrated by themselves, and the behavior of the interest rate apparently does not explain that deviation in the levels.[3]

Table 3 provides summary information about the VAR. Preliminary F-tests are consistent with reducing each estimated autoregression from twelve to eight lags but are not consistent with reducing the lag lengths of the nominal income or interest rate regressions to four lags. All regressions are based on eight lags of the first differences of all of the variables.[4] The first rows of Table 3 present unconditional standard deviations of the variables and R^2s, the fractions of variation explained, of the regressions in the VAR. The R^2s are reasonably high. The table indicates that the inflation rate has a smaller standard deviation than either the growth of nominal income or the money stock, and the R^2 for the inflation-rate regression is substantially higher than the other R^2s.[5]

The other statistics in the table provide some evidence about the adequacy of the estimates and a normal approximation for the residuals. With the exception of nominal income growth, the results suggest that there are problems with assuming a normal distribution. The test for autoregressive conditional heteroskedasticity (ARCH) in the residuals indicates that all series other than nominal income have serially correlated squared residuals.[6] The non-zero values of the skewness and kurtosis statistics suggest that the distributions may be skewed and have "fat tails" but do not provide a statistical test. The next rows of Table 3 provide some evidence concerning the adequacy of symmetric or normally distributed error approximations. The sign test is a test whether the median residual equals the mean and

[3] A test for cointegration up to 1991 yields a different result: the series appear to be cointegrated. A related paper [Dwyer 1998] provides an analysis of the data in levels.
[4] Preliminary F-tests are consistent with reducing the lag length from twelve to eight lags but not from eight to four.
[5] As the next table indicates, this reflects the much higher serial correlation of the inflation rate.
[6] The test is Engle's [1982] test based on the number of observations and the squared correlation of the squared residual this period and last.

the signed-rank test is a test whether the distribution is symmetric conditional on the median equals the mean. Test statistics as large or larger in magnitude than those in the table are quite likely, which indicates that these test statistics provide no evidence inconsistent with the hypothesis of symmetry. The Shapiro-Wilk test statistics, though, suggest that a normal distribution is inconsistent with the residuals for both the interest rate and the money stock. Overall, the serial correlation of squared residuals is the strongest evidence inconsistent with using a time-invariant normal distribution for the residuals. Evidence in Barnhart and Dwyer [1999] indicates that this evidence of ARCH is due to the assumption of linearity of the autoregressions rather than to an error concerning the distribution of the errors. Pursuing this aspect of the data is beyond the scope of this paper and I continue to use linear regressions to summarize the data.

Table 4 summarizes the test results concerning whether the variables help to predict each other. The F-ratios in Table 4 are test statistics for testing null hypotheses that the coefficients of each variable are zero in each of the four equations. At usual significance levels, the money stock is quite helpful for predicting nominal income, as are the inflation rate and the change in the interest rate. The inflation rate is unrelated to all of the other variables even at the ten percent significance level. If the requisite significance level were raised to 17 percent or higher, the money stock would be "statistically significant" but the interest rate would not. The interest rate has a p-value of 43 percent in the inflation regression. Given the serial correlation evident in Figure 3, it is not surprising that money growth is less important than lagged values of the inflation rate itself for predicting future inflation. Overall, I conclude that money growth is important for helping to predict the future evolution of nominal income and more important than the other variables for predicting the inflation rate.

Figures 6 through 9 are plots of actual and predicted values as well as residuals from the vector autoregression. All variables are plotted as quarterly changes, and the quarterly changes in the logarithms of nominal income, the price level and the money stock are annual growth rates as are the residuals. The vertical scales of axes in the figures are not the same; as a result, sizes of movements are not comparable across figures. For all variables, a solid line indicates the actual values and the dashed line indicates the predicted values. The graphs of actual and predicted values include a horizontal reference line at the mean and the graphs of residuals include a horizontal reference line at their mean of zero.

Despite the prominence of the deviation of the price level from money per unit of output from 1992 to 1995 in Figure 1, errors predicting inflation do not appear to be out of line with earlier prediction errors. Figure 10 focuses directly on this issue. The upper panel in Figure 10 shows actual deviations of money per unit from the price level and those predicted one quarter ahead by the VAR. These deviations also can be interpreted as the ratio of money to nominal income – the inverse of velocity.[7] Because the differences between actual and predicted values of the ratio of money to income are so small that they are not easy to see, the bottom panel of Figure 10 shows the residuals.

It is striking that the estimated vector autoregression is quite capable of predicting the deviation of money per unit of output from the price level. The deviations that are not

[7] These deviations are computed using the logarithms of the variables for simplicity because the equations are estimated using the logarithms of the variables. Let $\ln X$ denotes the logarithm of X. The quantity equation is $MV = Py = Y$, where Y is nominal income. In logarithms, the deviation of money per unit of ouput from the price level can be written $\ln M - \ln P - \ln y = -\ln V$. Hence, the plot of the deviations is a plot of the logarithm of the inverse of velocity.

predicted actually are small relative to those for most of the last forty-five years. In general, disentangling the source of the prediction is tenuous and I do not attempt to do that here.[8] Even so, the source of the deviation between money per unit of output and the price level in Figure 1 appears to be predictable by the vector autoregression.

Of course, the vector autoregression is estimated over data for the whole period and it is quite possible that the VAR estimated over data that ends in 1991 would not have predicted the deviation. Would the decrease in money relative to income have been predicted by a VAR estimated through the end of 1991? For this purpose, I use coefficients estimated through the end of 1991 and compute one-step-ahead predictions for each quarter. Figure 11 shows the one-step-ahead predictions for 1992 through 1997 of the deviations of money relative to income. The upper part of the figure indicates that the fall in money relative to income is predicted by this VAR. This VAR predicts the fall even though the fall is beyond the range of past ratios of money relative to income. The VAR does underpredict the fall and does not recover from that error until 1997, but it does predict most of it This implies that the fall of the ratio of money to income, while beyond the range of prior data, is consistent with prior coefficients given the data.[9]

4 Conclusion

It would be hard to interpret the evidence in this paper as suggesting that money is uninformative as an indicator of inflation. Nominal income is related to money growth. It follows that real income growth, inflation or both are related to money growth. Virtually all

[8] Gordon and Leeper [1994] is an excellent example of an attempt to identify money demand and supply that nicely illustrates how difficult it is to identify them.

[9] This may not be so surprising for a VAR estimated using first differences but a VAR estimated using the levels of the series yields the same conclusion [Dwyer 1998].

economic theories suggest that the eventual effect of money growth on real income growth is small to none. Money growth is more useful for forecasting inflation than other variables besides past inflation.

The alleged uselessness of money for monetary policy is based in part on recent inexplicable deviations of the money stock from its prior relationships with other series. Such an interpretation of the data is not consistent with the statistical analysis. While the results in this paper are far from an explanation of the recent deviations, they do suggest that part of the explanation is consistent with patterns in the coefficients estimated before the deviations. While there is a large decrease in money relative to nominal income from 1992 to 1995, this decrease appears to be consistent with prior regressions.

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5 Data Appendix

Monthly data on seasonally adjusted values of M2 for 1948 through 1958 are from Robert Rasche at http://www.msu.edu/~rasche/research/money.htm on April 23, 1998. Monthly data on seasonally adjusted values of M2 for 1959 through 1997 are from the Federal Reserve Bank of St. Louis at http://www.stls.frb.org/fred/dataindx.html on April 7, 1998. These data are converted to a quarterly frequency by averaging the monthly averages of daily values. I do not use M1 because M1 in recent years is distorted by sweep accounts.

Quarterly data on Gross Domestic Product for 1947 through 1997 are from the Department of Commerce at http://www.stat-usa.gov/BEN/bea2/national/nipahist.html on April 16, 1998.

The annual data on the money stock are from Friedman and Schwartz [1982, Table 4.8, pp. 122-29] for 1900 through 1947 and are annual averages of the data from Robert Rasche and the Federal Reserve Bank of St. Louis thereafter. The definition of M2 has changed since the compilation by Friedman and Schwartz and the data based on the new definition of M2 are spliced to their data by the ratio in 1948. In 1948, the primary difference between Friedman and Schwartz's measure of M2 (and an earlier measure constructed by the Board of Governors) is the inclusion in the current version of M2 of saving deposits and small time deposits held in thrift institutions. An examination of the data suggests no reason that the choice of a year other than 1948 to splice the data would have affected the data materially.

The annual data on income are from Friedman and Schwartz [1982, Table 4.8, pp. 122-29] for 1900 through 1959 and from the United States Department of Commerce at http://www.stat-usa.gov/BEN/bea2/national/nipahist.html on April 22, 1998 for 1960 through 1997. Friedman and Schwartz's data on nominal and real income are nominal and real net national product in 1948 and later years. The data for later years are net national product in current dollars and real net national product in chained 1992 dollars. These data are spliced by their ratio in 1959, the first year in which net national product currently is readily available.

Table 1. Correlations of Money, Income and the Price Level United States, I/1953 to IV/1997

	Growth Rate of Money	*Growth Rate of Nominal Income*	*Growth Rate of Real Income*	*Inflation Rate*
Quarterly				
Growth Rate of Money	1.000			
Growth Rate of Nominal Income	0.346	1.000		
Growth Rate of Real Income	0.223	0.818	1.000	
Inflation Rate	0.223	0.365	-0.238	1.000
Annual Average				
Growth Rate of Money	1.000			
Growth Rate of Nominal Income	0.594	1.000		
Growth Rate of Real Income	0.307	0.584	1.000	
Inflation Rate	0.376	0.565	-0.339	1.000
Two-year Annual Average				
Growth Rate of Money	1.000			
Growth Rate of Nominal Income	0.692	1.000		
Growth Rate of Real Income	0.303	0.362	1.000	
Inflation Rate	0.456	0.715	-0.392	1.000
Three-year Annual Average				
Growth Rate of Money	1.000			
Growth Rate of Nominal Income	0.754	1.000		
Growth Rate of Real Income	0.275	0.257	1.000	
Inflation Rate	0.543	0.789	-0.391	1.000
Four-year Annual Average				
Growth Rate of Money	1.000			
Growth Rate of Nominal Income	0.790	1.000		
Growth Rate of Real Income	0.209	0.178	1.000	
Inflation Rate	.614	.827	-.407	1.000
Five-year Annual Average				
Growth Rate of Money	1.000			
Growth Rate of Nominal Income	.824	1.000		
Growth Rate of Real Income	.177	.102	1.000	
Inflation Rate	.661	.861	-.419	1.000

Table 2. Test Statistics for One or More Cointegrating Vectors in the Estimated Vector Autoregression, United States, I/1953 to IV/1997

Rank	Test Statistic	Critical Value 95 percent
0	31.185	54.11
1	17.509	34.56
2	10.737	18.15
3	0.877	3.84

The critical values are from Johansen [1995, p. 216.] The results for a vector autoregression with no trend are similar.

TABLE 3**. Summary Statistics for the Estimated Vector Autoregression, United States, I/1953 to IV/1997**

STATISTIC	***First Difference of*** Nominal Income (logarithm)	Price Level (logartithm)	Interest Rate on Treasury bills	Money Stock (logarithm)
Std. Dev. Variable	1.004	0.601	0.029	0.972
Std. Dev. First Differenced Variable	0.042	0.025	0.008	0.037
Std. Dev. Residuals	0.033	0.011	0.006	0.026
R^2	0.483	0.846	0.461	0.580
LaGrange Multiplier Test for ARCH	0.036 (0.849)[a]	4.218 (0.040)	5.030 (0.025)	3.802 (0.051)
Skewness of Residuals	0.305	0.303	-0.480	0.974
Kurtosis of Residuals	1.248	0.350	4.928	4.940
Sign Test	-5 (0.502)	-2 (0.823)	2 (0.823)	4 (0.602)
Sign Rank	-197 (0.779)	-200 (0.776)	349 (0.619)	-220 (0.754)
Shapiro-Wilk	0.983 (0.588)	0.987 (0.799)	0.949 ($<10^{-3}$)	0.960 (0.001)

a. The p-values of test statistics are in parentheses.

Table 4. TESTS OF RESTRICTIONS ON ESTIMATED EQUATIONS IN THE VECTOR AUTOREGRESSION UNITED STATES, I/1953 TO IV/1997

TEST[a]	VARIABLE			
	Nominal Income (logarithm)	*Price Level (logarithm)*	*Interest Rate on Treasury Bills*	*Money Stock (logarithm)*
No lagged income	2.492 (0.015)	0.542 (0.823)	1.82 (0.078)	0.735 (0.661)
No lagged price level	2.605 (0.011)	27.646 ($<10^{-3}$)	1.141 (0.196)	4.218 ($<10^{-3}$)
No lagged interest rate	2.584 (0.011)	1.005 (0.435)	8.708 ($<10^{-3}$)	3.466 (0.001)
No lagged money stock	4.219 ($<10^{-3}$)	1.419 (0.168)	1.219 (0.292)	7.171 ($<10^{-3}$)

a. The test statistics are F-ratios for testing the null hypothesis that all coefficients on the lagged values of the variable are zero in each regression. The degrees of freedom of the F-ratios are eight and 147. The p-value are provided in parentheses.

Figure 1

The Price Level and Money Relative to Real Income
1953 to 1997 Quarterly United States

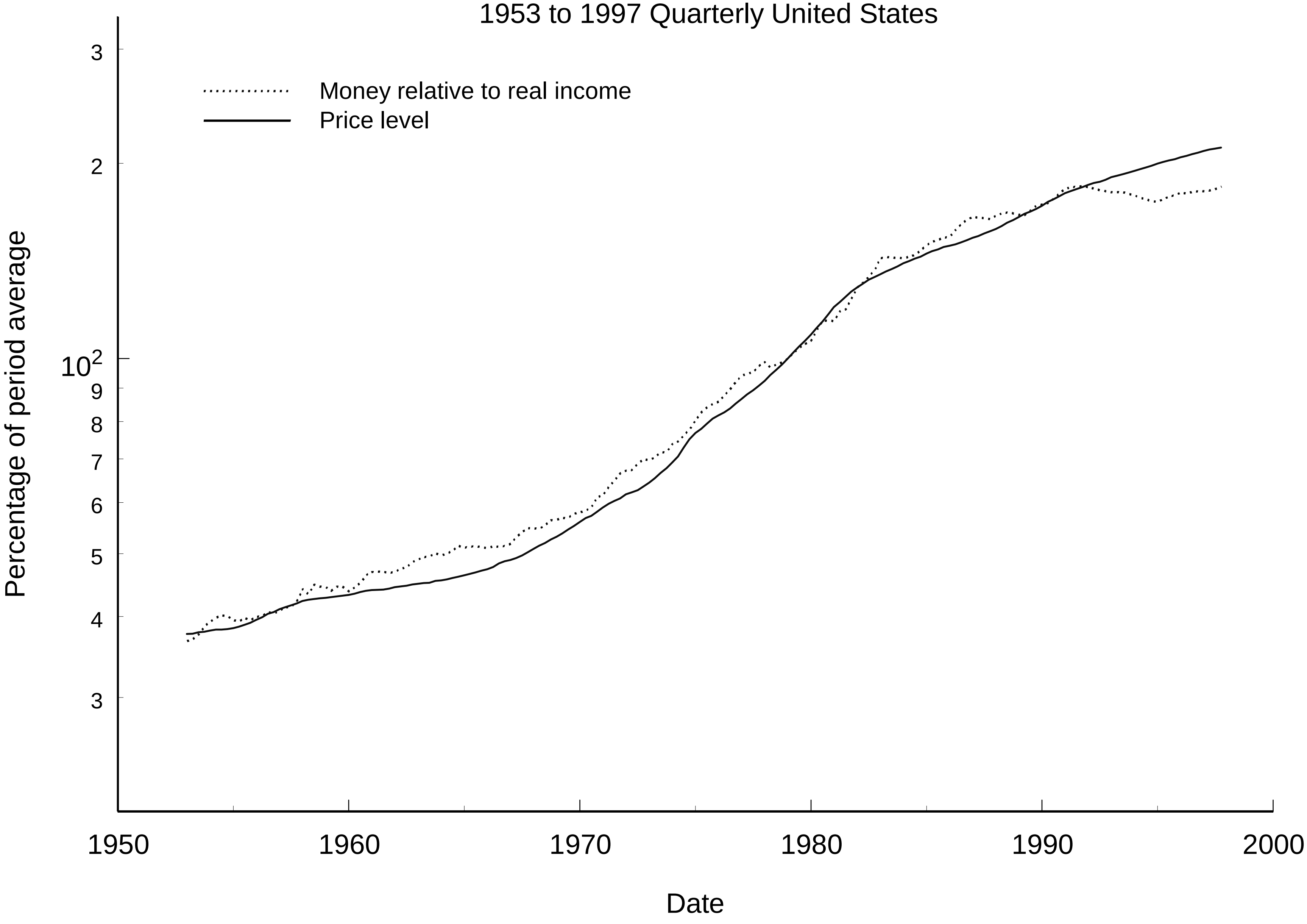


Figure 2

The Price Level and Money Relative to Real Income

1900 to 1997 Annual United States

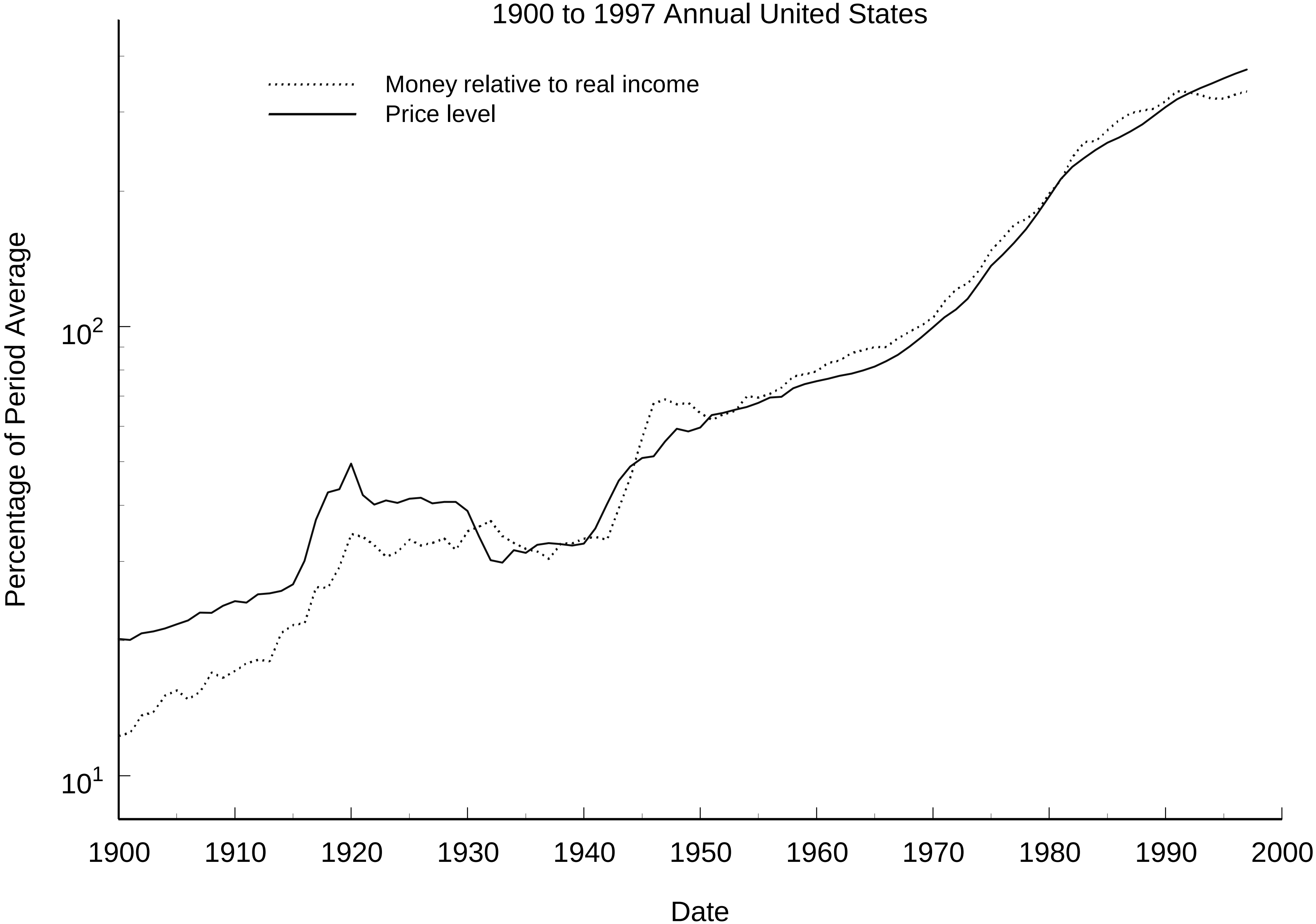
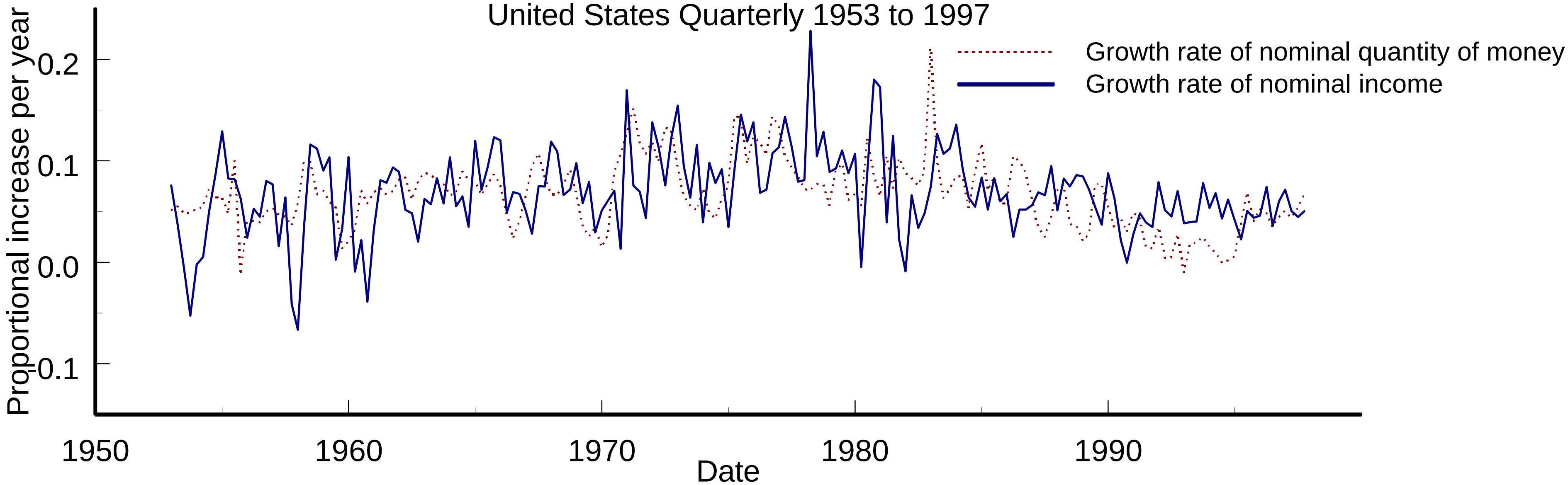


Figure 3

The Growth Rate of Money, the Growth Rate of Nominal Income and the Inflation Rate

United States Quarterly 1953 to 1997



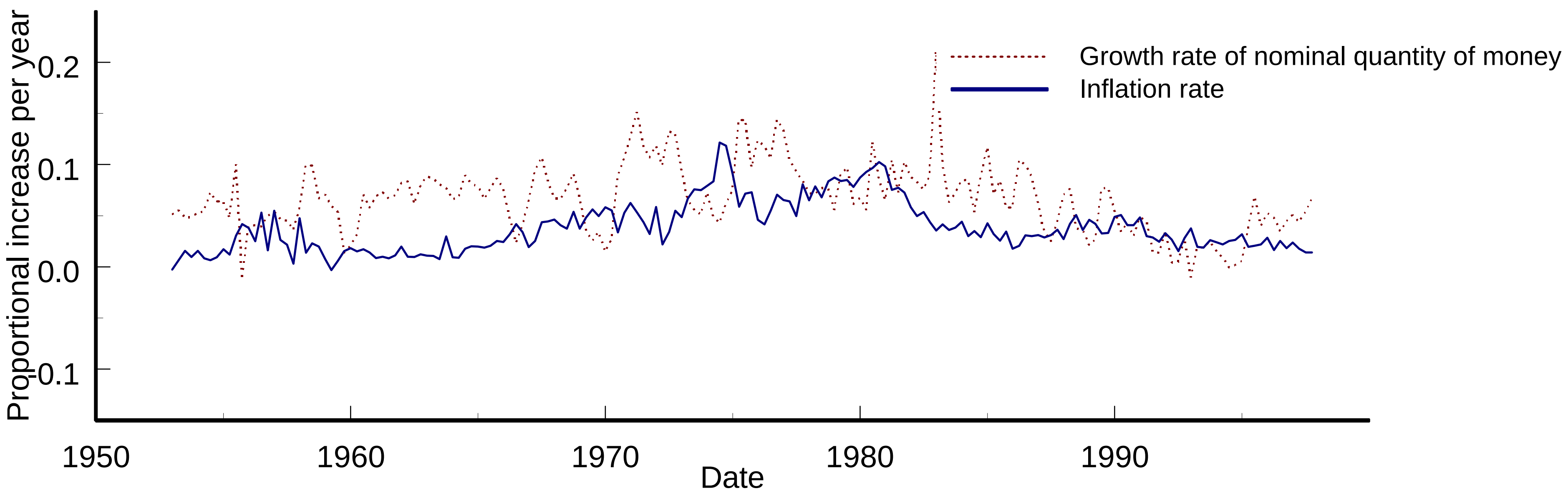


Figure 4

The Growth Rates of Money and Nominal Income Averaged over Different Periods

1953 to 1997 United States

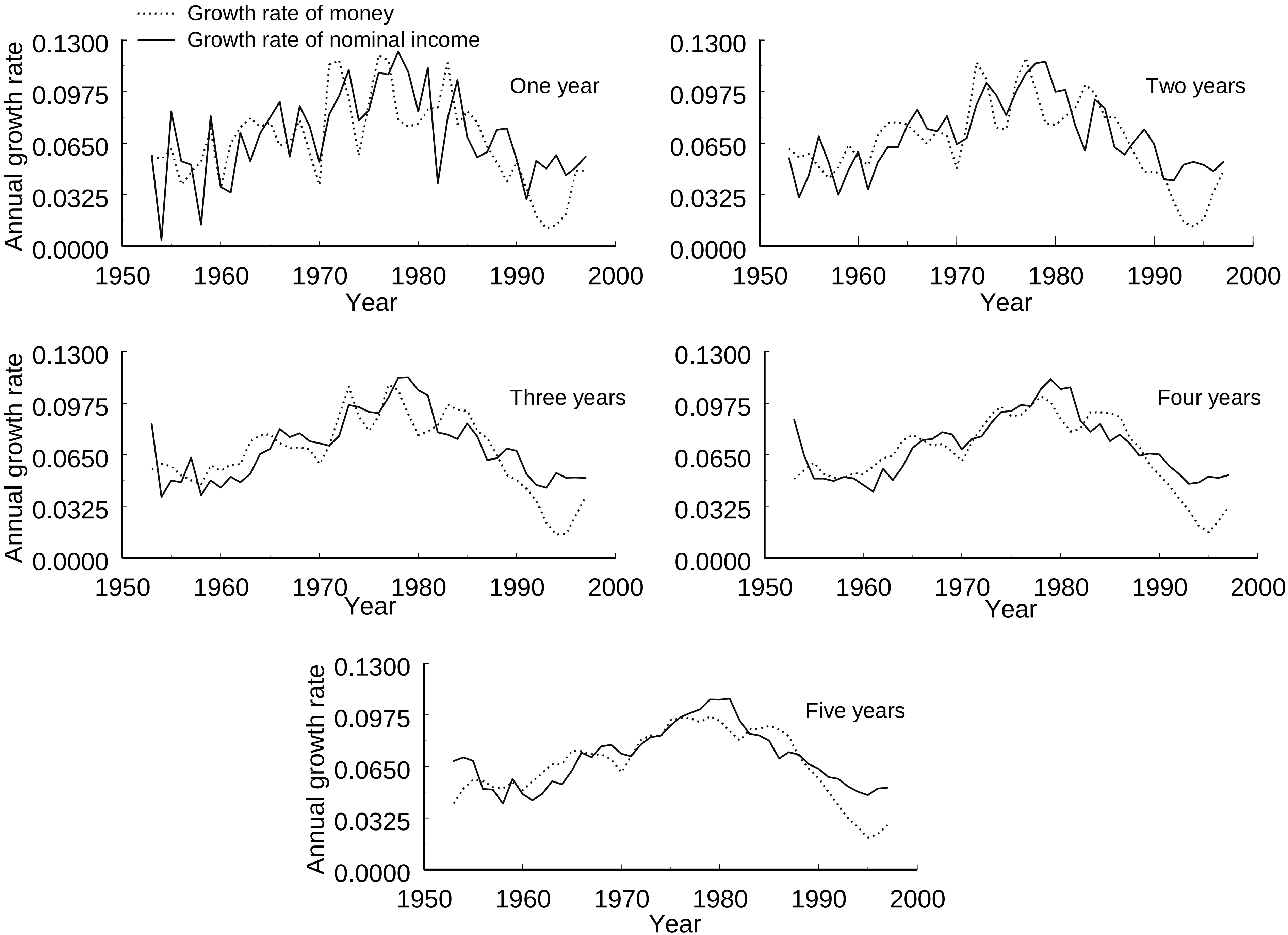


Figure 5

The Growth Rates of Money and the Inflation Rate Averaged over Different Periods

1953 to 1997 United States

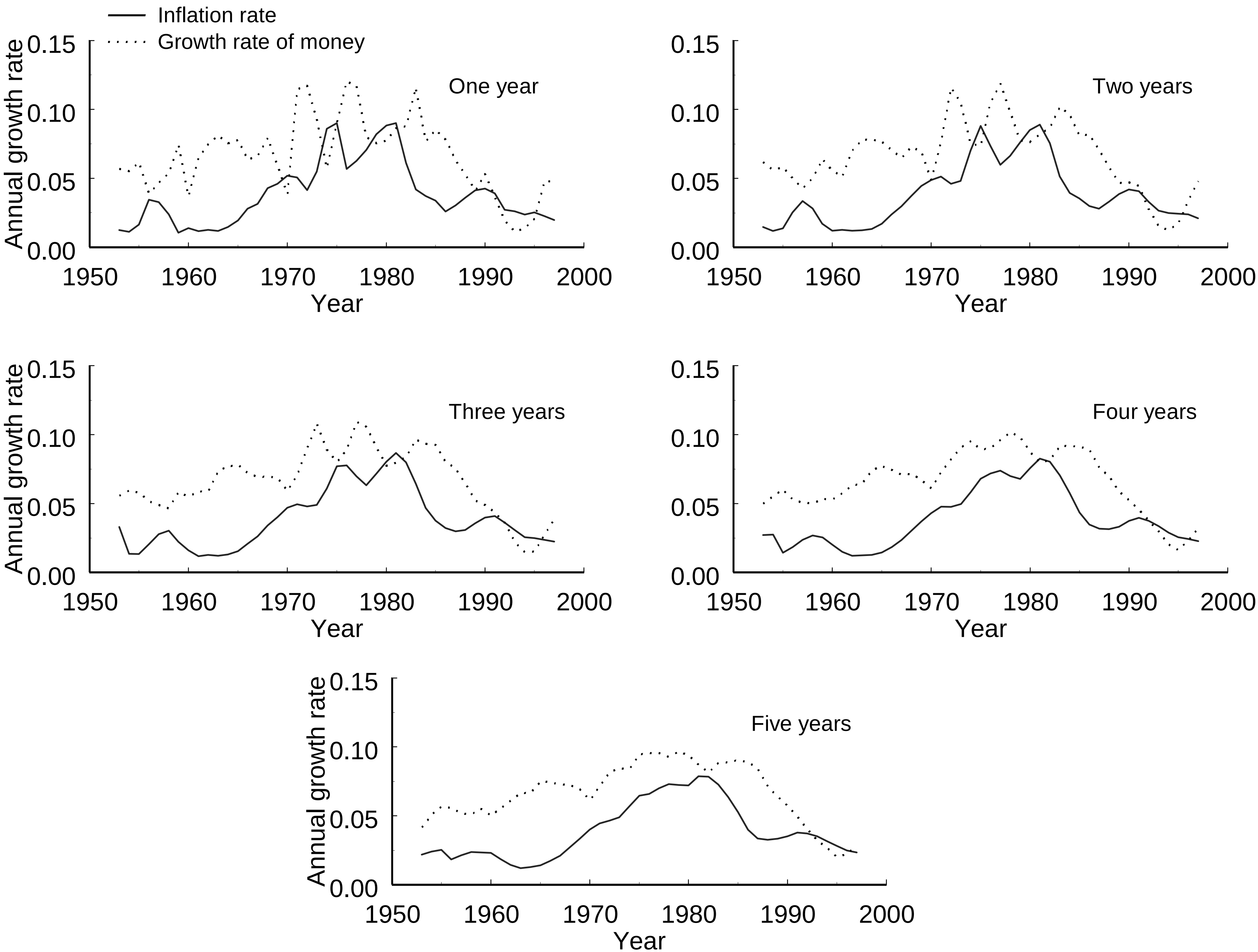


Figure 6

Actual and Predicted Values of the Growth Rate of Nominal Income

1953 to 1997 United States

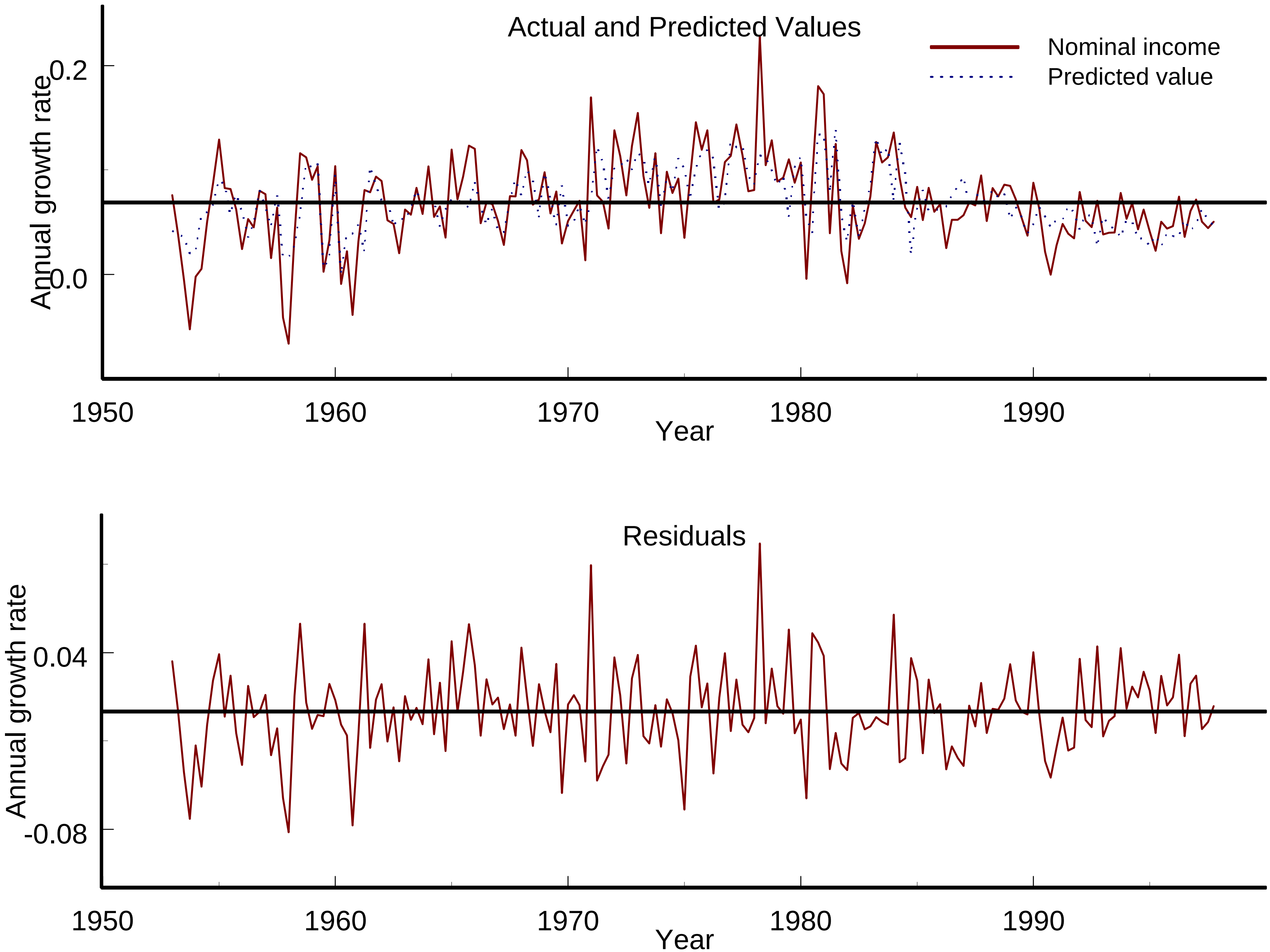


Figure 7

Actual and Predicted Values of the Inflation Rate

1953 to 1997 United States

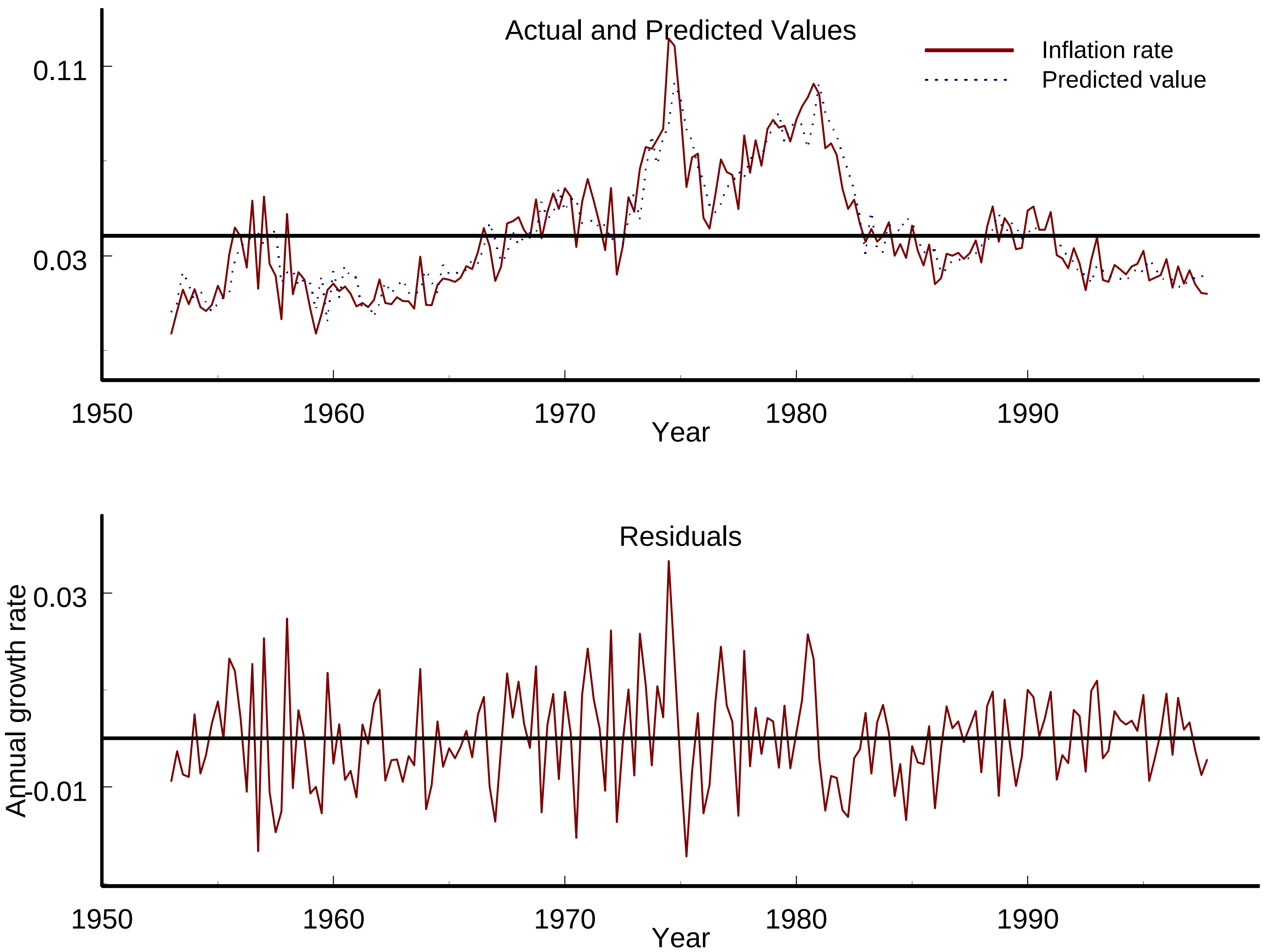


Figure 8

Actual and Predicted Values of the Change in the Interest Rate
1953 to 1997 United States in Proportional Terms

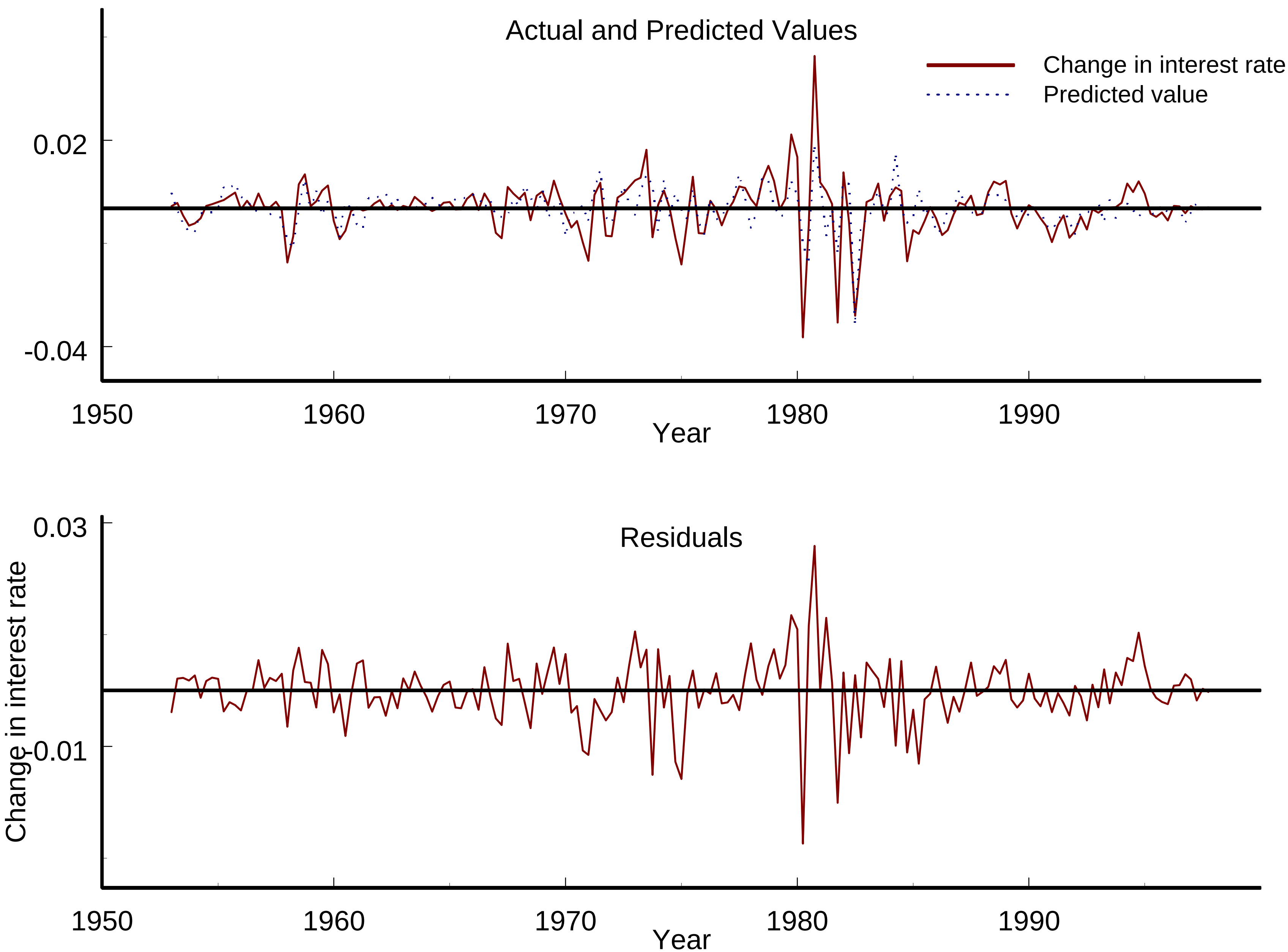
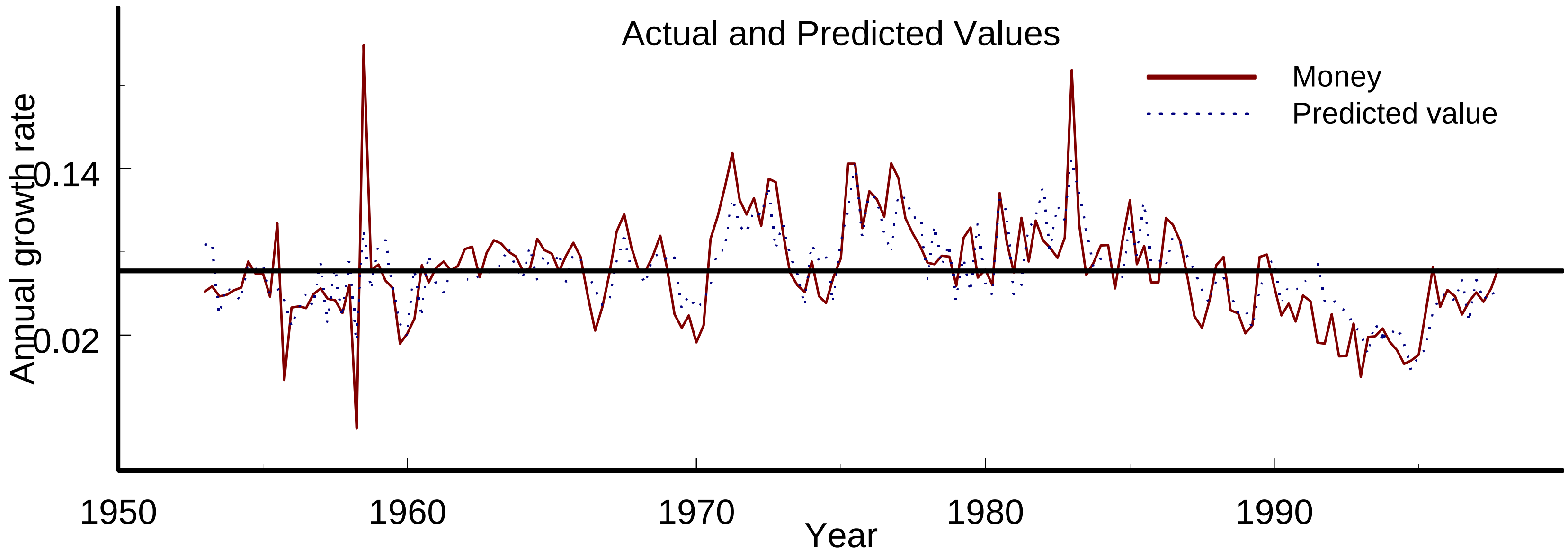


Figure 9

Actual and Predicted Values of the Growth Rate of Money

1953 to 1997 United States



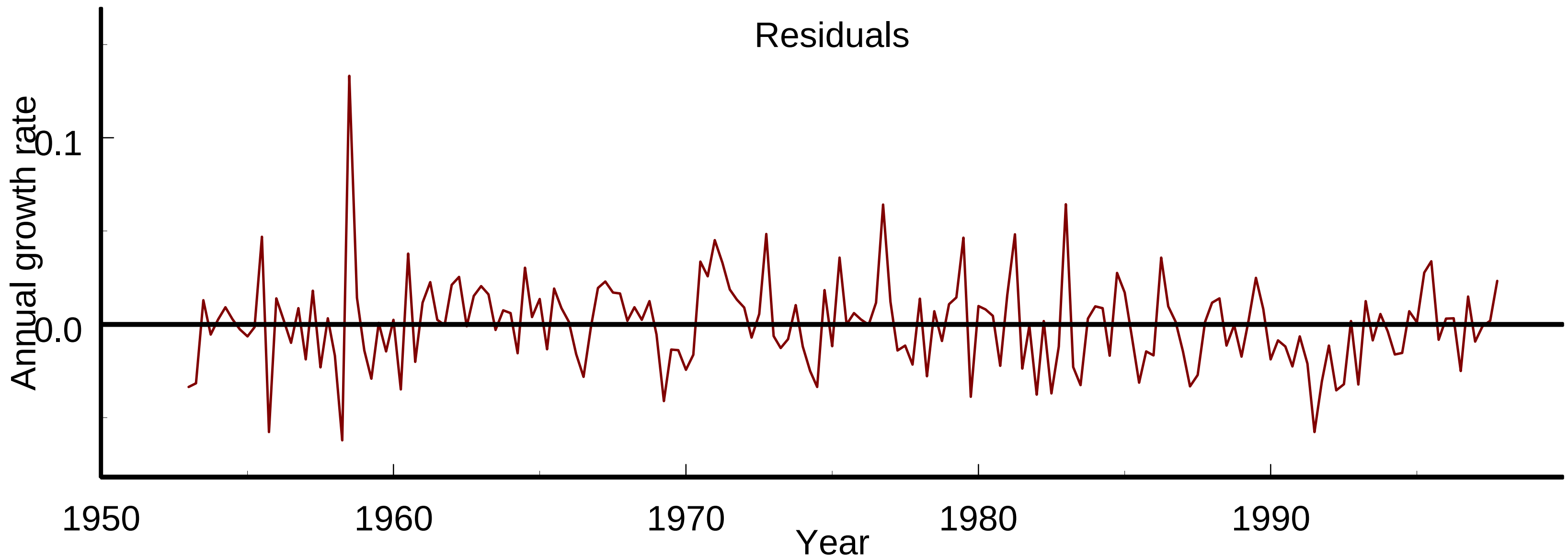
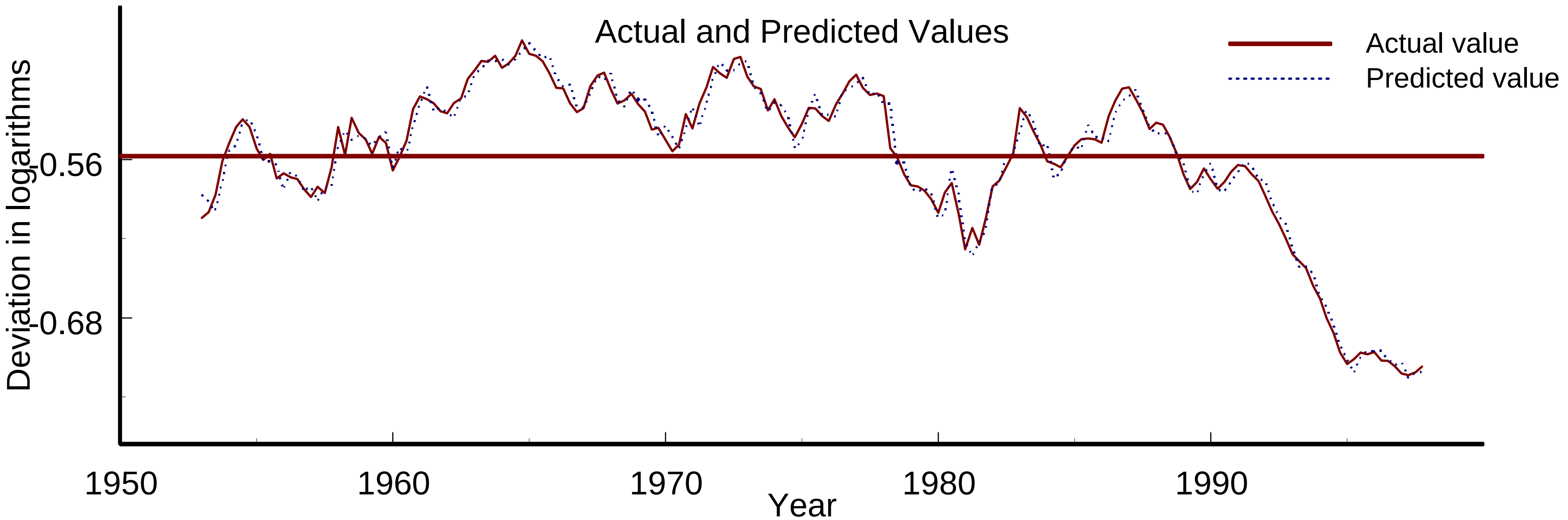


Figure 10

Actual and Predicted Values of Deviations of Money Relative to Income from the Price Level

1953 to 1997 United States



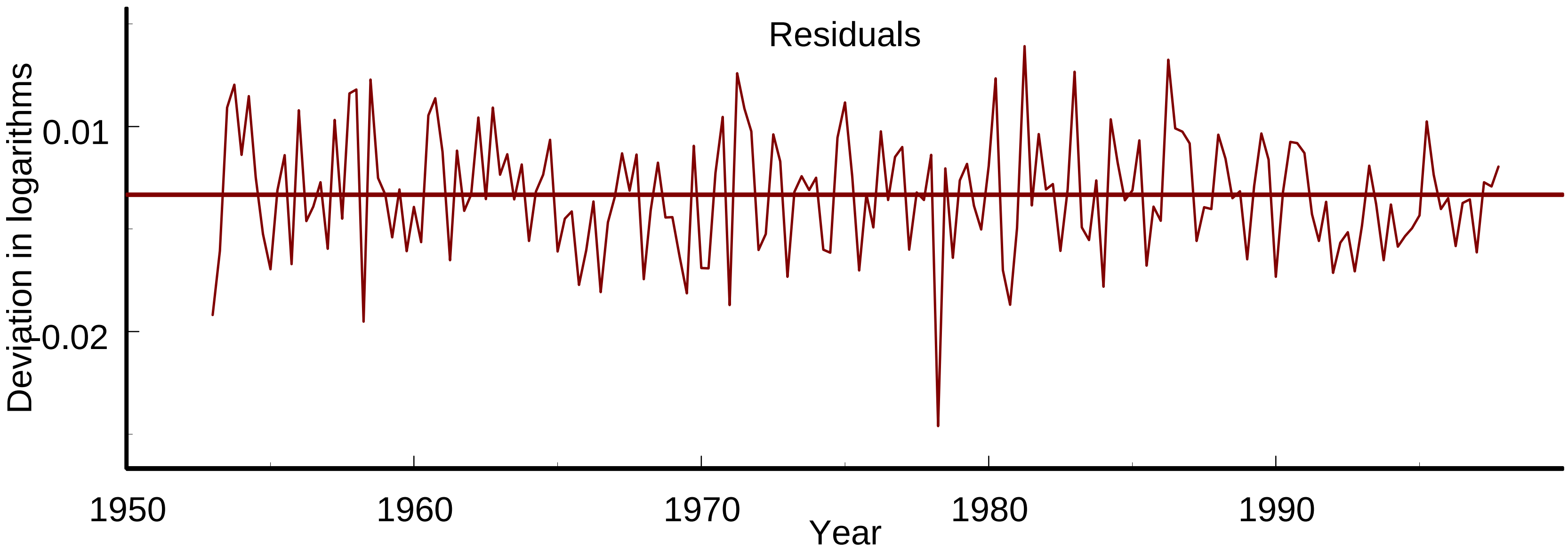


Figure 11

Actual and Predicted Values of Deviations of Money Relative to Income from the Price Level

Regressions through 1991

1953 to 1997 United States