

## The relation between U.S. money growth and inflation: evidence from a band-pass filter

Gary Shelley

*Dept. of Economics Finance; East Tennessee State  
University*

Frederick Wallace

*Dept. of Management Marketing; Prairie View  
AMUniversity*

### *Abstract*

Christiano and Fitzgerald (2003) found a significant, positive correlation between M2 money growth and CPI inflation in all examined frequency bands for the U.S. prior to 1961. However, for post-1960 data, they found a positive correlation only in the frequency band corresponding to cycles of 20-40 years. Using their filter, we verify this result and extend the pre-1961 sample to include the monetary base and inflation calculated from the GDP deflator. In addition, we extend their post-1960 analysis to include growth in the monetary base, M1, and M3. A strongly positive correlation between post-1960 money growth and inflation exists only for the broad money aggregates and within the 20-40 year frequency band.

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## 1. Motivation and Methodology

As a practical application of their band pass filter, Christiano and Fitzgerald (2003), examined cycles in United States M2 money growth and CPI inflation that fall into frequency bands corresponding to 2-8 years (business cycle frequencies), 8-20 years (long run frequencies), and 20-40 years (very long run frequencies).<sup>1</sup> Using annual data for the period from 1900 through 1960, they find that the correlations between components of money growth and inflation are significantly positive and that the correlation increases as one moves from the business cycle to lower frequency bands. However, the results are markedly different when they examine data from 1961 through 1997. For this data sample, they find that the correlations between filtered money growth and CPI inflation are negative in both the business cycle and the long run frequency bands. A significant, positive correlation between money growth and inflation is found only for the very long run frequency band.

The Christiano and Fitzgerald results suggest that a significant change has occurred in the relationship between money growth and inflation. Their finding implies that Milton Friedman's (1968) famous statement that inflation is "always and everywhere a monetary phenomenon" now may be valid only in the very long run. Given the potential importance (and possibly controversial nature) of their results, we seek to verify their findings for the U.S. using a slightly different data set, and then extend their analysis by including other money aggregates and inflation as measured by the GDP deflator.

The Christiano and Fitzgerald band pass filter (hereafter denoted as the CF filter) provides a method for examining cyclical components of a time series that move in different frequency bands. For example, suppose one wants to study the cycles in an economic time series,  $\{x_t\}$ , that correspond to business cycle frequencies of 2-8 years. There exists an orthogonal decomposition:

$$x_t = y_t + \tilde{x}_t, \quad (1)$$

where the  $y_t$  component has power only in the business cycle frequencies and the  $\tilde{x}_t$  component has no power within these frequencies. The  $y_t$  series then is the cyclical component of  $x_t$  of interest. Christiano and Fitzgerald show that the  $y_t$  component can be estimated in the frequency domain by minimizing the conditional expected mean squared error:

$$\text{Min} : E[(y_t - \hat{y}_t)^2 | \{x_t\}]. \quad (2)$$

The CF filter is referred to as a "band pass" filter because the  $\tilde{x}_t$  component is allowed to pass through the filter leaving only an estimate,  $\hat{y}_t$ , of the component that has power within the frequency band of interest.<sup>2</sup> In this paper, if  $x_t$  is a money growth (or inflation) series, then we will refer to the estimated  $\hat{y}_t$  series as "filtered" money growth (or "filtered" inflation).

The CF filter is not limited to extracting the component of a series corresponding to the business cycle frequencies, although it handles this task quite well. The filter is particularly useful for examining the longer term, or lower frequency, components of an economic series. Analysis of the long run components of an economic series is not possible using the earlier Hodrick-Prescott (1997), or HP, filter. The HP filter is best interpreted as a high-pass filter isolating frequencies of 8 years and higher in economic data and is not intended for frequencies

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<sup>1</sup> "Long run" and "very long run" are used in this paper to characterize these frequency bands. This terminology was not used in the CF paper.

<sup>2</sup> Programs for estimating the filtered series using a variety of statistical software are available at the homepages of both Christiano and Fitzgerald.

falling into other bands. In addition, adjustments for handling annual, quarterly, and monthly data are quite simple with the CF filter, yet are problematic for the HP filter. Finally, Christiano and Fitzgerald find that their filter dominates the Baxter-King (1999) version of a band pass filter (referred to as the BK filter) in terms of their optimality criterion, particularly when examining bands of lower frequency than the business cycle. One reason for its dominance is that the CF filter uses all observations of a series while the BK filter does not. The CF filter thus provides a useful framework for study of the long run relationships between economic series.

## 2. Data and Results

We first seek to verify Christiano and Fitzgerald's finding that there is a positive correlation between M2 money growth and CPI inflation for pre-1961 U.S. data. We extend their examination of the pre-1961 era by also looking at growth in narrow money as measured by the monetary base (MB) and by examining inflation measured by growth in the GDP deflator. Annual CPI data are obtained from the Bureau of Labor Statistics web site. Annual MB and M2 are the money series used by Coe and Nason (2002) in their test for the long run neutrality of money.<sup>3</sup> The GDP deflator was obtained from Johnston and Williamston (2004). In all cases, growth rates refer to the log-differenced series. Using data from 1914 through 1960, we separate the growth rates of narrow money (MB), broad money (M2), and the two price indexes into the three sets of frequency bands used by Christiano and Fitzgerald.

Results from the CF band pass filter using the 1914-1960 annual money and CPI inflation data are presented in Panel 1. Results using M2 as the money measure are shown in the column of graphs on the left, while results using the monetary base are displayed in the column of graphs to the right. In each case, the top row of graphs shows the business cycle component of each series. The middle row of graphs displays the long run components, while the bottom row shows the very long run components. Results using the percentage change in the GDP deflator as the measure of inflation are presented in the same manner in Panel 2. In both panels, money growth and inflation appear to move together in all frequency bands, with the co-movement especially striking for the 8-20 year (long run) and 20-40 year (very long run) frequency bands. This observation is confirmed by the contemporaneous correlations between filtered money growth and inflation in each frequency band provided in Table I. Each correlation is positive and most are larger than .4. Further the correlations of M2 growth and inflation move closer to unity as the frequency diminishes. The correlation between growth in the monetary base and inflation is somewhat stronger at the long run frequency than at the very long run frequency, although the differences in the correlations are not large. These results support the finding of Christiano and Fitzgerald for the pre-1961 period.

We next examine money growth and inflation for the period 1959-2002. We extend the analysis of Christiano and Fitzgerald by including three additional money measures, the monetary base (MB), M1, and M3. Again inflation is measured as log differenced growth rates in both the CPI and the GDP deflator. For this analysis, monthly money growth is matched with the monthly growth rate of the CPI. Similarly, we match quarterly money growth with quarterly growth in the GDP Deflator. Data series are from the Federal Reserve Bank of St. Louis.

The filtered, monthly narrow money growth and CPI inflation series are presented in Panel 3. Results for MB are presented in the left column of graphs, and results for M1 are presented in the right column of graphs. Filtered broad money growth and CPI inflation are presented in Panel 4, with results using M2 growth displayed on the left hand side of the page and results using M3

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<sup>3</sup> We are grateful to Coe and Nason for providing their data series.

displayed on the right. In each panel, the business cycle components, long run components, and very long run components are presented in each successive row of graphs. Inspection of Panels 3 and 4 reveals no apparent positive co-movement between filtered CPI inflation and money growth (either narrow or broad) in the 2-8 year or 8-20 year frequency bands. Thus, the money-inflation relationship at 2-8 and 8-20 year frequencies differs sharply with that observed for the 1914-1960 period. Not only do the results differ from the earlier period, but there are negative correlations between the business cycle and long run components of money growth and inflation as displayed in Table II. At business cycle frequencies, for example, M2 growth and inflation as measured by the CPI have a correlation of  $-.68$  for the 1959-2002 period compared with a correlation of  $.44$  for these two variables prior to 1961. The very long run (20 to 40 year) positive relation between money growth and inflation still appears to hold in this sample for MB, M2, and M3; but, interestingly, not for M1

The filtered quarterly money growth and GDP deflator inflation series are presented in Panels 5 and 6, with the graphs arranged in the same manner as in the two preceding panels. Similar to our findings for the monthly series, there is no apparent positive co-movement between money growth and inflation in either the 2-8 or 8-20 year frequency bands. In this case the only strongly positive relation between the plotted filtered series is for broad money growth and inflation in the 20-40 year frequency band. As before, these observations are confirmed by the correlations between the filtered series (presented in Table III). All but one of the correlations between money growth and inflation in the 2-8 and 8-20 year frequencies are negative for the 1959-2002 period, and the single positive correlation is small. A strong, positive correlation between money growth and inflation is found only for M2 and M3 and only in the very long run, 20-40 year, frequency band. Surprisingly, the strong correlation ( $.85$ ) between base money growth and CPI inflation weakens considerably ( $.24$ ) when the deflator is used to measure inflation.

### **3. Conclusions**

We have verified Christiano and Fitzgerald's result that a strong positive correlation between M2 growth and CPI inflation existed prior to 1961 in all examined frequency bands. This result is robust for a narrow money measure and for inflation measured by the GDP implicit price deflator. Their finding that the positive relation between M2 growth and CPI inflation in the 2-8 and 8-20 year frequency bands disappears after 1960 in the US is also confirmed. Extending the study to include the MB, M1, and M3 money aggregates and the GDP deflator as a price index, we find that the positive relation between money growth and inflation of the earlier period no longer holds in the business cycle and long run frequency bands for these additional series during 1959-2002. Results suggest that a strong, positive correlation between money growth and inflation still exists only for broadly defined money (M2 and M3) and only for the very long run frequency band of 20-40 years.

Two questions are raised by this study. First, is the apparent breakdown in the relation between money growth and inflation limited to the United States? Second, if inflation is no longer linked to money growth at the business cycle and long run frequencies, then what are the causes of cyclical and long run inflation since 1960?

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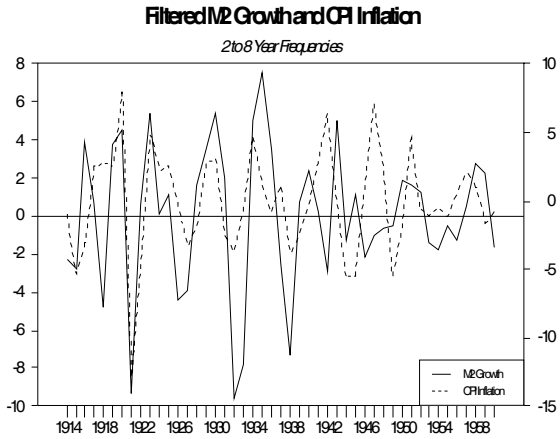
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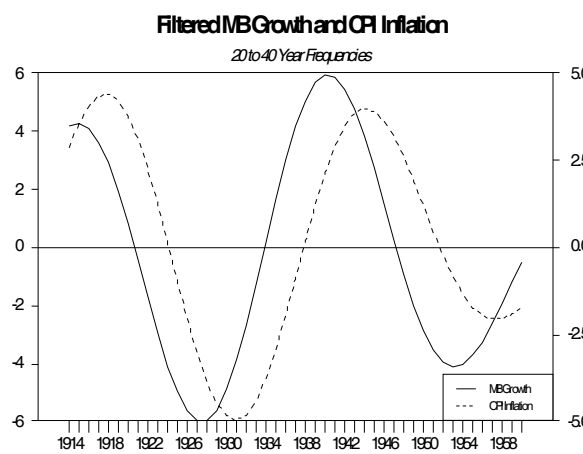
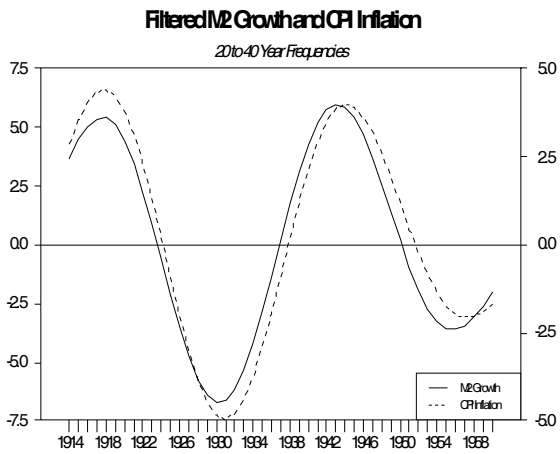
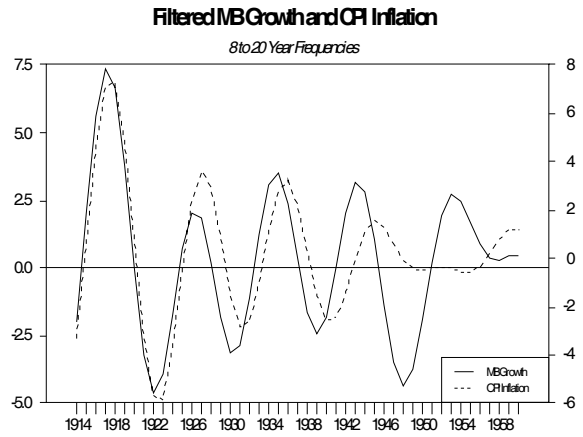
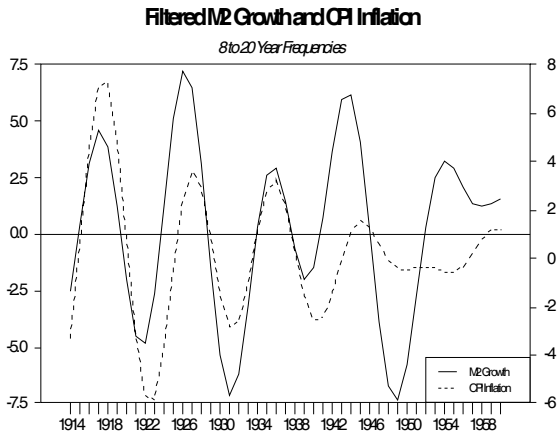
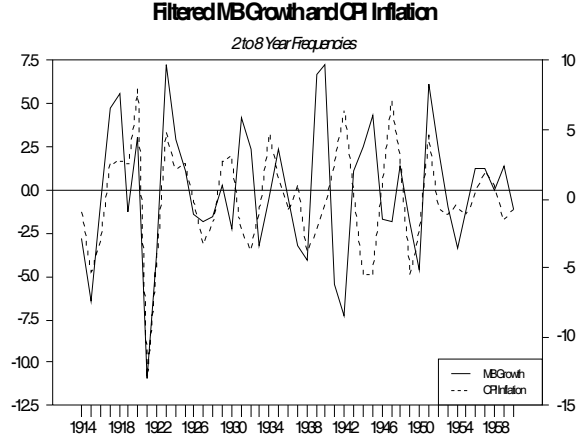
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**Panel 1**  
**Filtered Annual Money Growth and CPI Inflation**  
**1914-1960**

**M2 and the CPI**

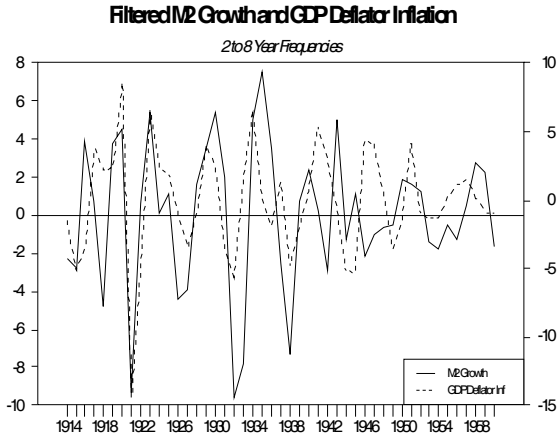


**M1 and the CPI**

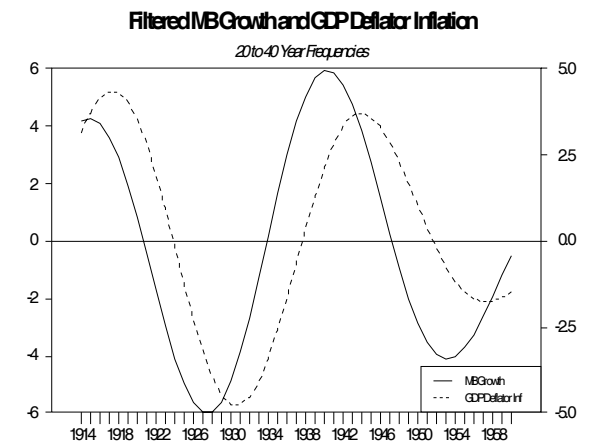
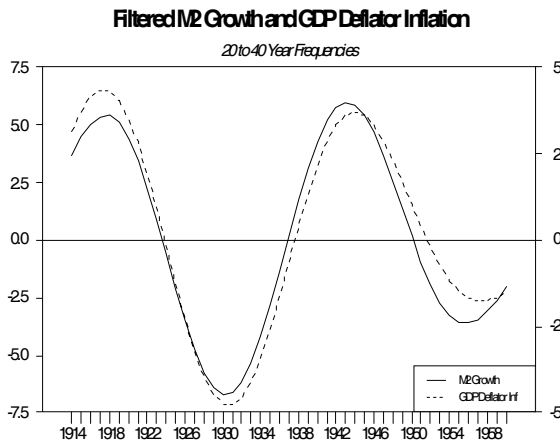
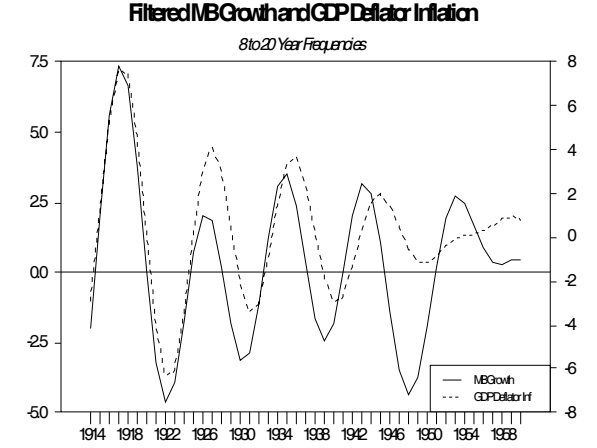
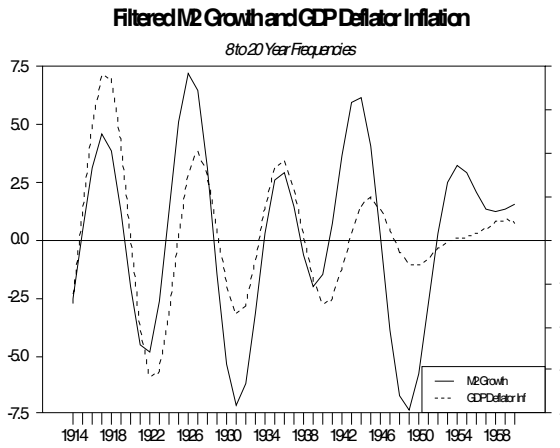
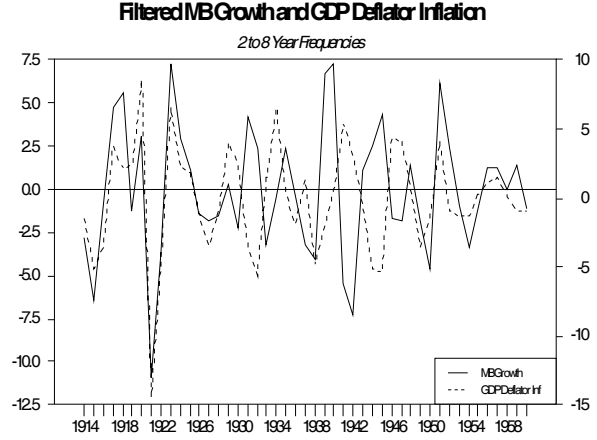


**Panel 2**  
**Filtered Annual Money Growth and GDP Deflator Inflation**  
**1914-1960**

**M2 and the GDP Deflator**



**MB and the GDP Deflator**



**Table I**  
**Correlations between Filtered Money Growth and Inflation**  
**1914-1960**

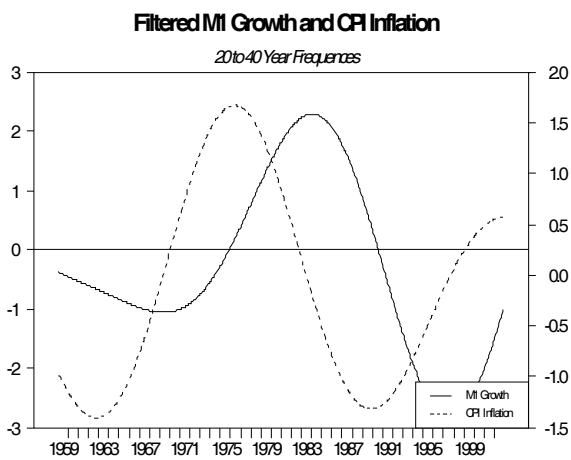
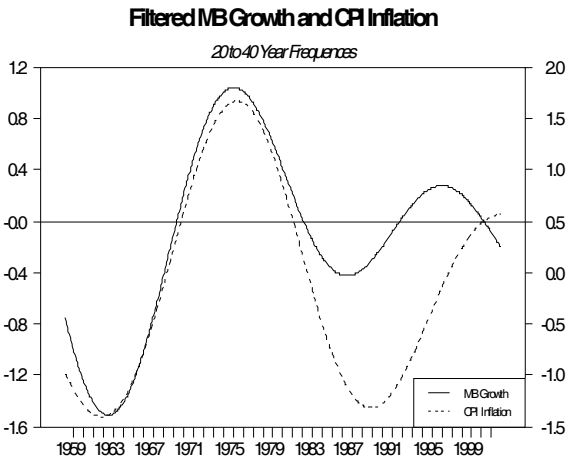
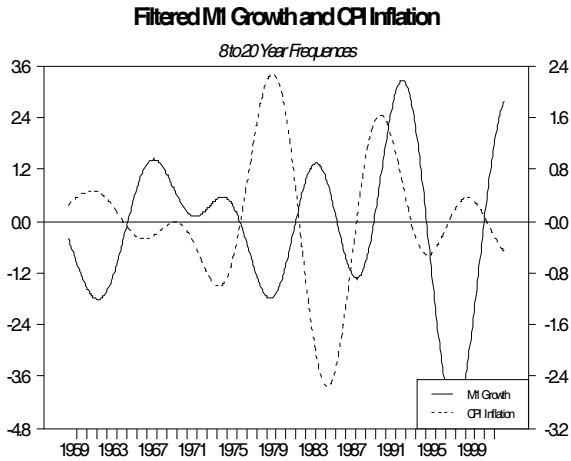
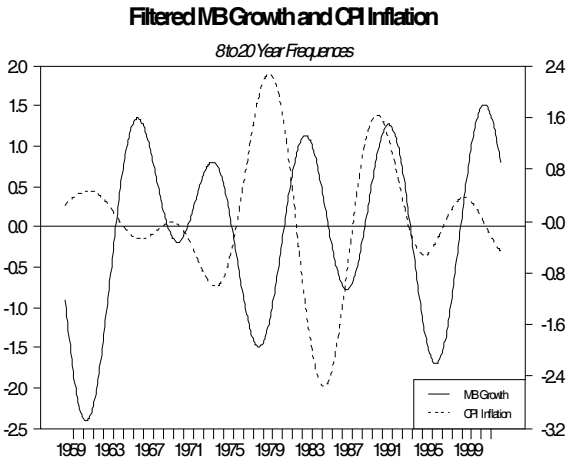
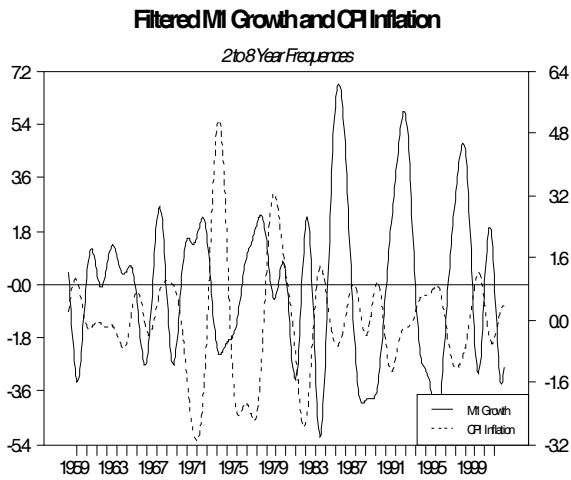
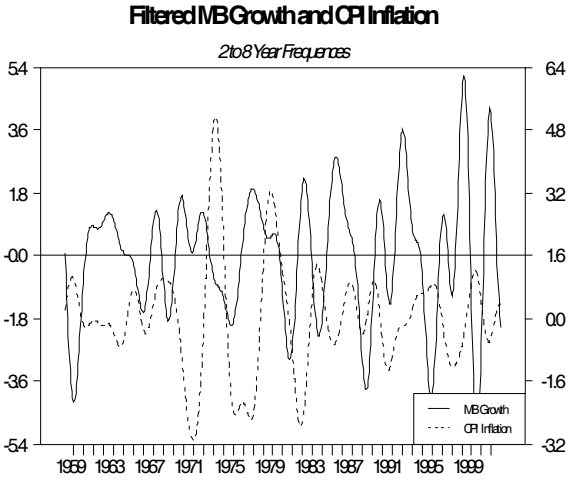
<b>Frequency</b>	<b>M2 &amp; CPI</b>	<b>MB &amp; CPI</b>	<b>M2 &amp; GDP Deflator</b>	<b>MB &amp; GDP Deflator</b>
<b>2-8 years</b>	.4386	.3117	.4781	.3390
<b>8-20 years</b>	.5511	.7467	.6308	.7949
<b>20-40 years</b>	.9757	.6405	.9793	.6757



**Panel 3**  
**Filtered Monthly Narrow Money Growth and CPI Inflation**  
**1959:2 - 2002:12**

**MB and the CPI**

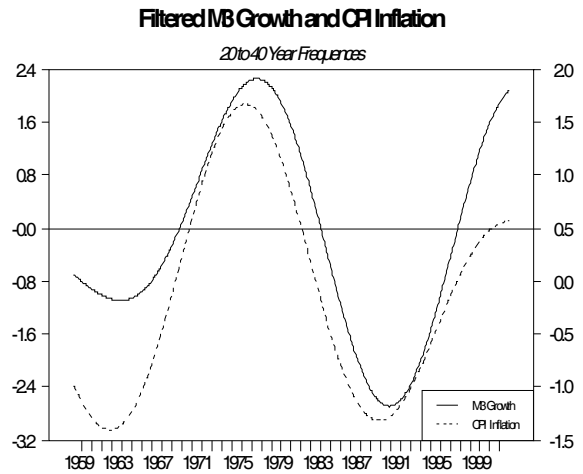
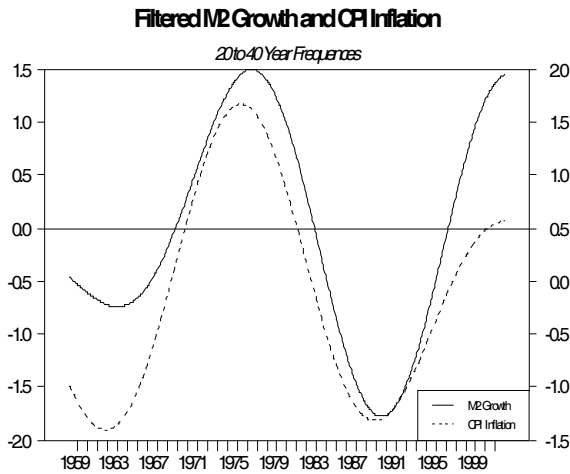
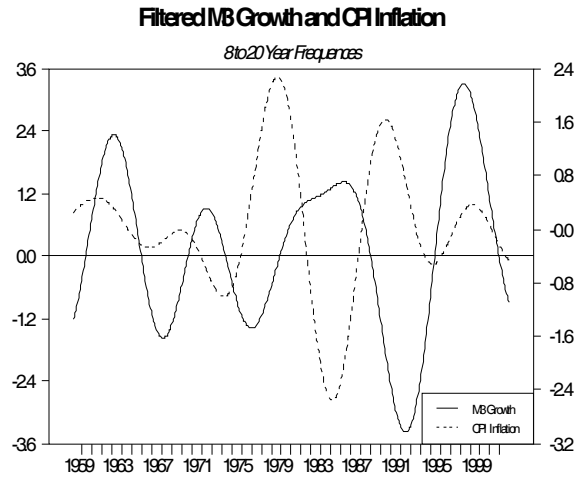
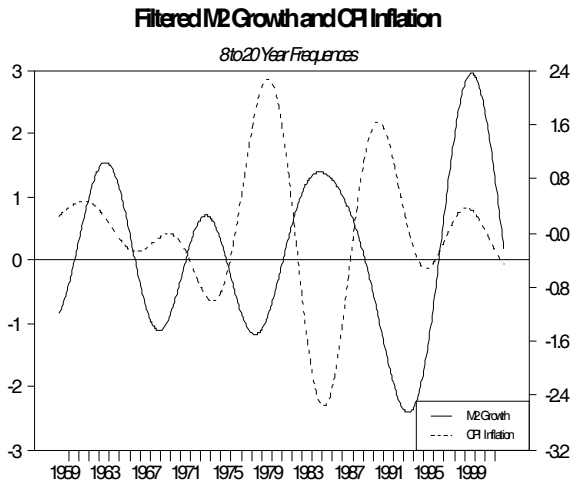
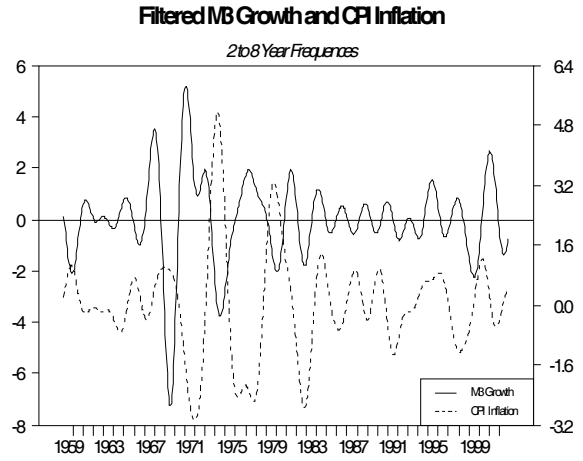
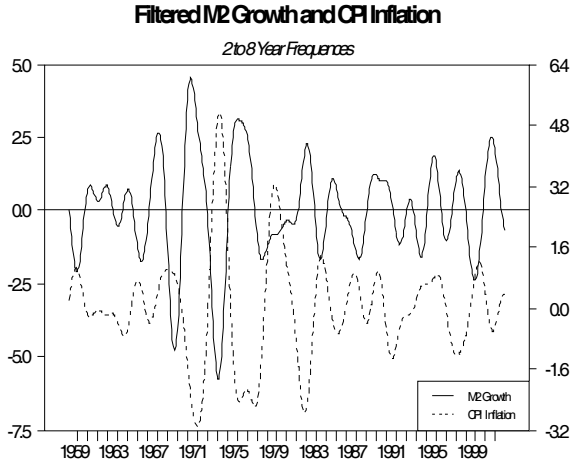
**M1 and the CPI**



**Panel 4**  
**Filtered Monthly Broad Money Growth and CPI Inflation**  
**1959:2 - 2002:12**

**M2 and the CPI**

**M3 and the CPI**



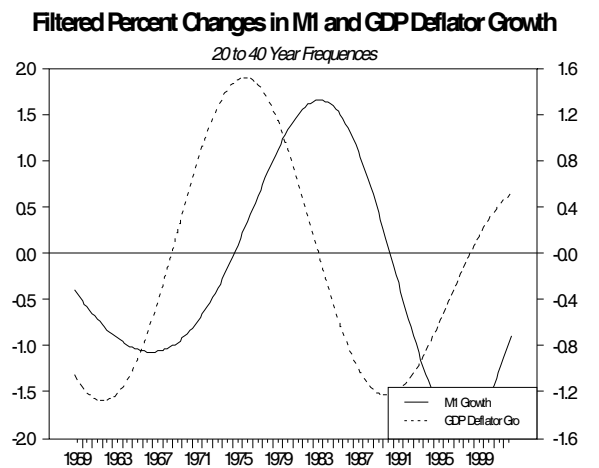
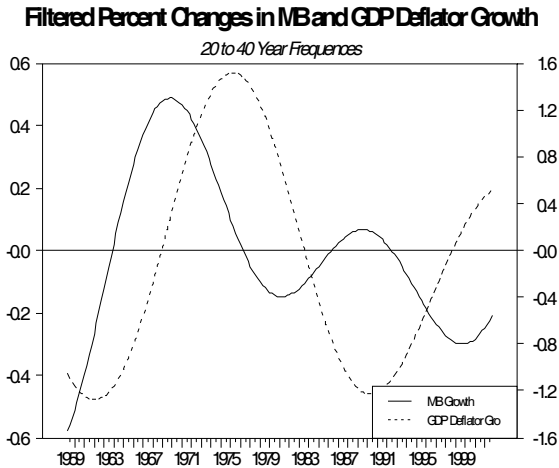
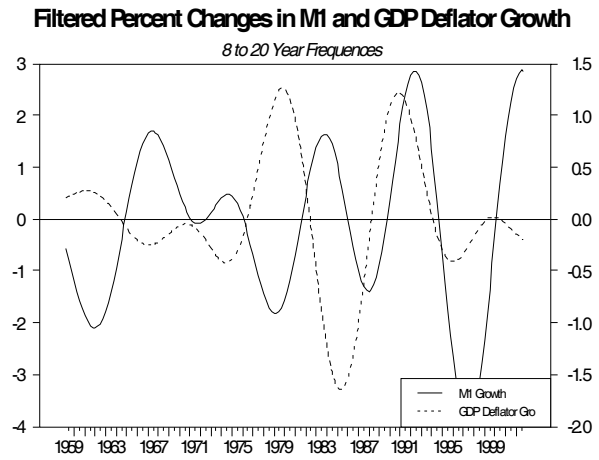
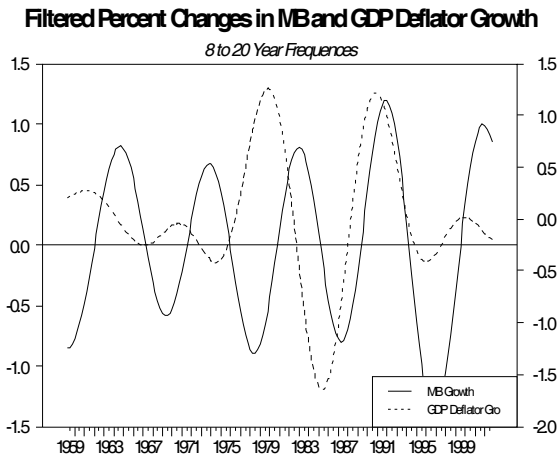
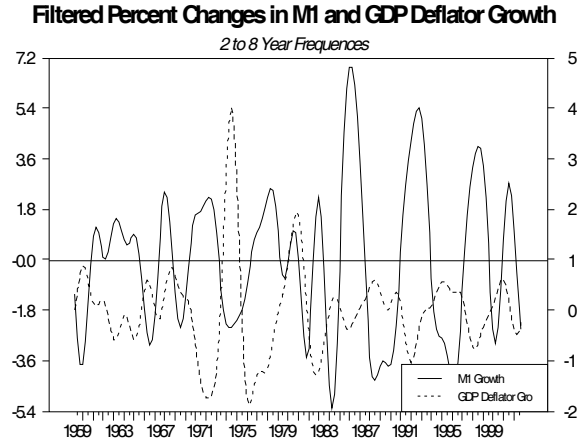
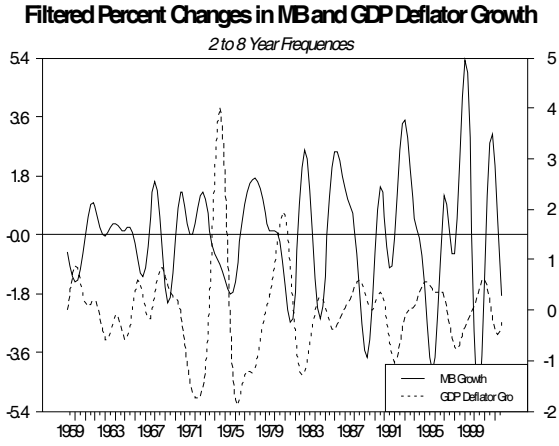
**Table II**  
**Correlations between Filtered Monthly Money Growth and Inflation**  
**1959:02 - 2002:12**

<b>Frequency</b>	<b>MB &amp; CPI</b>	<b>M1 &amp; CPI</b>	<b>M2 &amp; CPI</b>	<b>M3 &amp; CPI</b>
<b>2-8 years</b>	-.2473	-.3868	-.6800	-.4247
<b>8-20 years</b>	-.2321	-.2370	-.3556	-.2851
<b>20-40 years</b>	.8459	.0767	.9231	.9239

**Panel 5**  
**Filtered Quarterly Narrow Money Growth and GDP Deflator Inflation**  
**1959:2 - 2002:4**

**MB and the GDP Deflator**

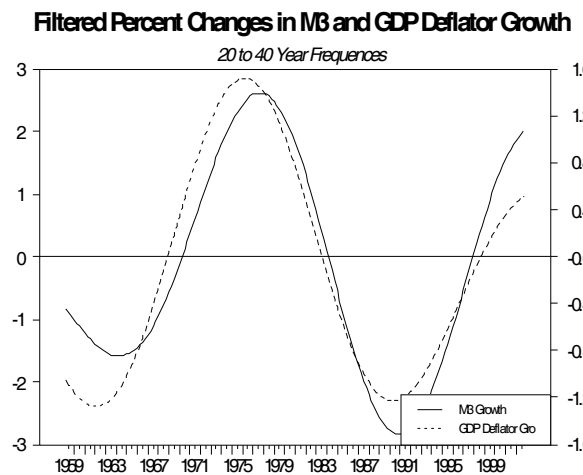
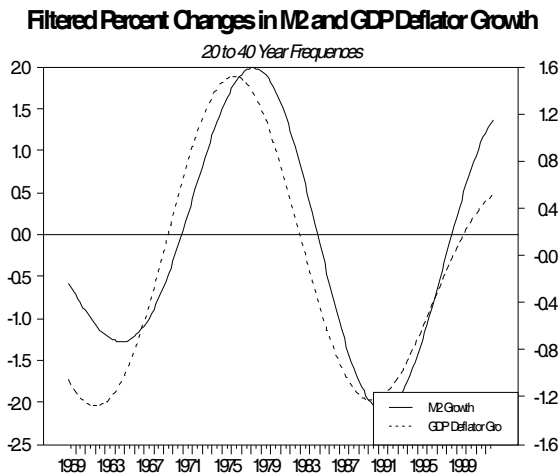
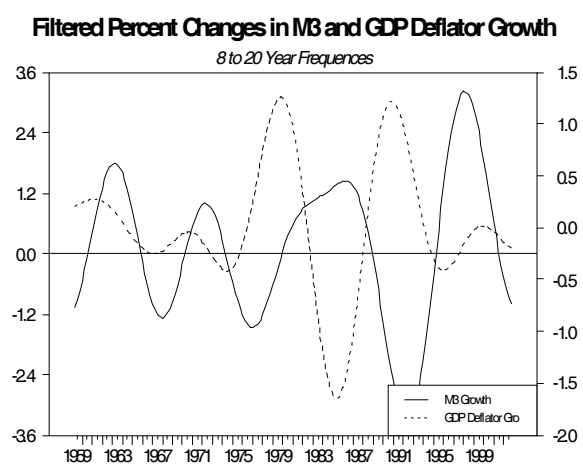
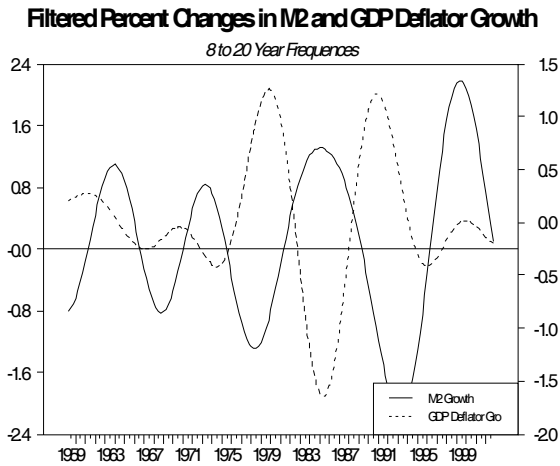
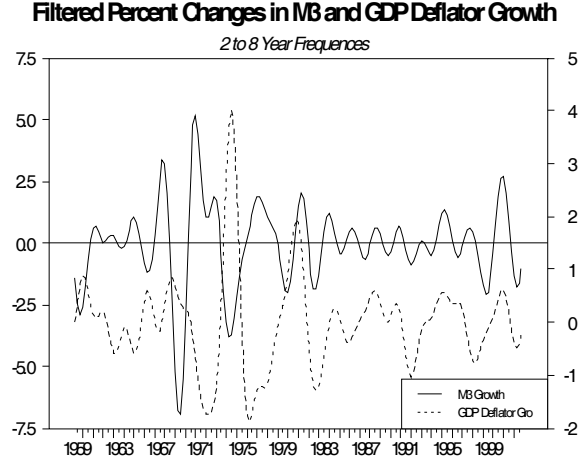
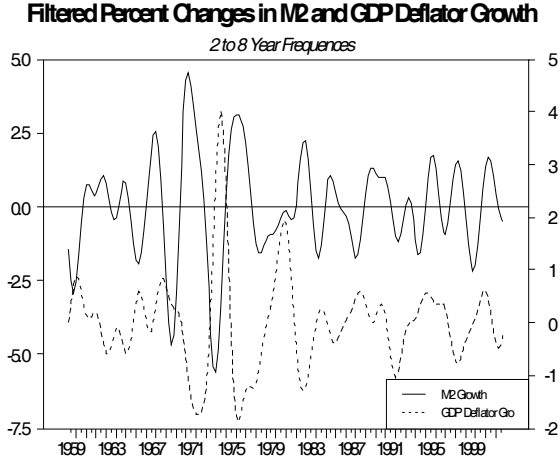
**M1 and the GDP Deflator**



**Panel 6**  
**Filtered Quarterly Broad Money Growth and GDP Deflator Inflation**  
**1959:2 - 2002:4**

**M2 and the GDP Deflator**

**M3 and the GDP Deflator**



**Table III**  
**Correlations between Filtered Quarterly Money Growth and Inflation**  
**1959:2 - 2002:4**

<b>Frequency</b>	<b>MB &amp; Deflator</b>	<b>M1 &amp; Deflator</b>	<b>M2 &amp; Deflator</b>	<b>M3 &amp; Deflator</b>
<b>2-8 years</b>	-.3285	-.4255	-.5130	-.3717
<b>8-20 years</b>	.1009	-.0746	-.5467	-.4598
<b>20-40 years</b>	.2349	.2031	.9214	.9410