Money-Inflation Relationship: Band Spectrum analysis approach

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Abstract

Researchers in Pakistan endorse strong linkage between monetary growth and inflation. The stability, over different time horizons, remains unsettled which has serious monetary policy implications. Keeping this in mind we use band spectrum regression applying conjugate analysis to examine the Quantity theory of money. We find that the relationship holds only for low frequencies.
Introduction

Inflation is a serious problem in most of the economies. Economists have done extensive research on causes and cures of inflation failing to establish a consensus. One of the main causes highlighted in literature is high money growth. A major part of literature deals with analyzing this relationship. For example, Grauwe and Polan-2005 studied 160 countries for more than 30 years and found strong association between high (hyper) inflation or deflation and money growth rate whereas in countries with low and stable inflation, this association was weak. Pakistan has a volatile inflation history\(^1\). So there can be strong relationship between money growth and inflation in Pakistan. Most of the literature supports this hypothesis\(^2\); however the existence of this relationship across different components (frequencies) of the variables is still unsettled.

In this paper we want to assess whether this relationship holds for different frequency bands. For policy makers this analysis is very important. If, for example, policy makers are informed that relationship holds only for low frequencies, they might not want to change policies against temporary shocks that fade away within policy target time horizon. In other words, policy makers just need to filter out high frequency money growth rate as a meaningful indicator of inflation.

We will follow Assenmacher-Wesche and Gerlach (2006) who investigate the relationship between money growth and inflation over different band of frequencies for Japan, Euro area and Swiss Bank. For their analysis, they use band spectral analysis technique and demonstrate that the relationship between money growth and inflation holds only for low frequencies, for high frequencies output gap causes inflation.

Figure 1.a shows average lead of low frequency inflation against the band of low frequency money growth ranges from 0 to 25 in the period extending from 1960 to 2008. It is clear from the chart that money and inflation has strong positive relationship (89%) correlation) at low frequencies, whereas, figure1.b shows weak

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\(^1\) e.g In 1967 annual inflation rate was -4.85% and in 1974 it reached 30%.

\(^2\) Qayyum 2006, Kemal-2006
relationship between these variables at high frequencies. This is consistent with literature\(^3\) and motivates us for further analysis.

![Figure 1.a](image1.png) ![Figure 1.b](image2.png)

Note: x-axis has money growth while y-axis reflects inflation rate

The paper is arranged as follows. In section II, we will present brief literature review about the money inflation relationship in Pakistan. In section III we discuss the econometric model and the evaluating methodology which is based on Assenmacher-Wesche and Gerlach (2007). We will also discuss econometric issues of data in this section. In section IV, we will present the econometric results. Conclusion and relevant policy implications will be presented in section VI.

**II. Money growth and inflation in Pakistan**

Hossain (1990) tested the monetarist vs. New Keynesian visions for high inflation in Pakistan, Sri Lanka, Bangladesh, India, and Nepal. The important finding of this study is that bond-financed government expenditures have no significant impact on the acceleration of inflation independently. Their results support Monetarist view who believes that bond financing has no real impact on aggregate demand and prices until the money is held constant. Their study consistently holds up the monetarist view that growth of real money balances is the sole determinant of long run inflation.

Ahmad (1991) also finds money growth as an important determinant of inflation. Khan and Schimmelpfennig (2006) using the monthly data try to determine the drivers of inflation in Pakistan. They mainly use wheat support price, exchange rate, interest rate, money supply, credit to private sector as a test variable in their model. Results show that monetary factors play dominant role in headline CPI inflation. The impact of these variables appears on prices with a one year lag. They show that growth rate of broad money and private sector credit can be used as leading indicators of inflation in Pakistan.

Qayyum (2006) attempted to examine whether Quantity theory of money is applicable in Pakistan. He finds that changes in money supply affects real GDP growth which in turns affects the inflation in Pakistan. The significant conclusion from the study is that excess money supply growth is a leading indicator of inflation during the study period.

Similarly Kemal (2006) finds that Quantity theory of money holds for Pakistan in long run. However the impact of money growth appears after 9 months. Significant result that comes out from this study is that system takes long time to converge the equilibrium whenever system faces shocks in any of the variables among prices, money supply or GDP.

Husain (2006) stated comparable results. According to his study, taking care of shifts, there exist unidirectional causality from money to prices in long run and no causality in short run.

III. Empirical model

Inflation is “a monetary phenomenon” can best be described by quantity theory of money. Following Gerlach (2004) we assume that low frequency component of inflation is explained by the quantity theory of money and high inflation component is explained by output gap where we use the lag of one period for the explanatory variables. The complete model is defined as

\[
\pi_t = \pi_t^l + \pi_t^h = g_{mt-1}^l + \beta_g g_{yt-1}^l + \beta_y y_{t-1} + \delta_t
\]

Since we do not have independent data series for velocity, we include velocity in error term.
\( g_{mt} \) and \( g_{yt} \) show growth of money and income at time \( t \). \( g_t \) reflects output gap at time \( t \). QTM predicts that \( \beta_m = 1 \), \( \beta_y < 0 \) (proportionality) and \( g_{mt} \) and \( g_{yt} \) are uncorrelated (orthogonality).

**Inflation, money, and output growth**

This paper uses annual data from 1960 to 2008. The variables money growth and inflation are taken from International Financial Statistic (IFS) CD ROM. We used Hodrick-Prescott (HP) filter for output gap.

Figure 2 shows the power spectrum for the stationary variables, inflation, money growth and output growth for frequencies less than 0.5 Hz. The most apparent crest for inflation and money growth is approximately 16 year cycle whereas for output growth it is 24 year cycle. The relative power of 16 year component is 25% and 26% for money growth and inflation respectively and for output growth rate it is 23%. Both inflation and money growth share the same frequencies.

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5 Spectrum analysis needs stationarity. We applied different test to check unit root in inflation, money growth, and output gap series. These variables appear to be stationary.

6 In figure 2, solid line shows output growth, dashes show growth of money and dots are for inflation.
Figure 2 demonstrates that inflation has positive relationship with money growth and negative relationship with output growth within low frequency band. It is apparent from graph that money growth leads the inflation in low frequencies.

**IV. Estimation and results**

We estimated the model using band spectrum regression which was initially developed by Engle (1974). In our analysis, we first convert the data from time domain into frequency domain and then eliminate specific components. By conjugate analysis we selected significant frequencies and then develop high and low frequencies bands. This technique is appropriate in our analysis because we try to analyze the inflation determinants on different band of frequencies. In our case, we divide whole data into two groups: high frequency and low frequency bands. After defining the bands we applied the inverse Fourier transform to recover filtered time series data. Spectral regression inconvenience results are as follows.

Table 1 (\( \pi_i = \sum_{j=1}^{2} \beta_{mj} g_{mt-j} + \sum_{j=1}^{2} \beta_{yj} g_{yt-j} + \sum_{j=1}^{2} \beta_{yj} g_{yt-j} + \sum_{j=1}^{2} \beta_{n} \pi_{yt-j} \), \( i = H, L \))

<table>
<thead>
<tr>
<th></th>
<th>Low frequency</th>
<th>High frequency</th>
<th>System estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money growth</td>
<td>0.74**</td>
<td>0.39*</td>
<td>0.68**</td>
</tr>
<tr>
<td>Output growth</td>
<td>-1.32**</td>
<td>-1.01</td>
<td>-1.38**</td>
</tr>
<tr>
<td>output gap</td>
<td>-0.2**</td>
<td>-0.23**</td>
<td>-0.27**</td>
</tr>
<tr>
<td>R^2</td>
<td>0.45</td>
<td>0.23</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Results reported in table 1, clearly indicate varying behaviour of the key variables along different band of frequencies. Here money and output growth explain inflation at low frequencies while at high frequencies only output gap has significant effect. At high frequency, money growth and output growth are statistically insignificant at 1% significant level. Here all variables have right signs. To check the proportionality hypothesis of QTM, i.e., money has one to one correspondence with inflation, we applied Wald test and find that a QTM assumption holds for low frequency band only. At higher frequency band, QTM

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7 Following Wesche and Gerlach (2006), Low frequency is defined as having fluctuations with a periodicity of 3 or more than 3 years.
hypothesis does not hold. For neutrality hypothesis we estimated following equation

\[ g_{yt}^i = \gamma_m g_{mt}^i + \mu_t \quad \text{for } i= \text{High, low} \]

And estimated results are given below

\[
\begin{array}{c|c}
  g_{yt}^l = 0.08 g_{mt}^l + \mu_t & g_{yt}^h = 0.082 g_{mt}^h + \mu_t \\
  \text{(1.84)} & \text{(2.00)}
\end{array}
\]

In both lower and high frequency case the coefficients on growth of money are not statistically different from zero. Therefore, it shows that neutrality holds for these cases.

For robustness analysis\(^8\) we estimated inflation equation by ARDL model. Results are presented in 3\(^{rd}\) column of table 1. They match with low frequency band

**V. Conclusion**

In low frequency bands both money and output growths explain inflation while at high frequency band output gap explains inflation. Results further indicate that proportionality hypothesis of QTM holds for low frequency band only where as neutrality holds for both cases.

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\(^8\) For robustness analysis I followed Assenmacher-Wesche and Gerlach (2006)
References


