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## Volume 31, Issue 1

### Monetary Policy, Asset Price Inflation and Consumer Price Inflation

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#### Abstract

The overall price level contains prices of everything purchased or purchasable (Fischer, 1911). The consumer price index only covers a small subset of all prices in the economy and since these prices are among the stickiest in the economy, this index may not fully capture the true rate of monetary inflation in the short run. Merging all price indices into one overall index has been rejected, not least for practical reasons. Issing (2003), though, argues that money growth can be interpreted as a proxy for the overall inflation rate; hence it is unnecessary to create a price index if the money growth rate can be used instead. This paper builds on Assenmacher-Wesche and Gerlach (2008a, b), and analyzes the relationship between money growth and different price indices such as the consumer price index, GDP deflator, share price index and house price index in eight developed countries. The results show that money growth is correlated with financial asset price inflation in the short, medium and long run. Real asset price inflation and money growth are correlated over the medium and long term and consumer inflation and money growth only over the long term. Since all movements in money growth, short term and long term, are associated with price changes, this paper concludes that money growth may serve as a proxy for the overall inflation rate.

## 1. Introduction

Monetary policy affects all prices in the economy, and a price index of the overall price level contains prices of everything purchased or purchasable (Fisher, 1911). How quickly monetary policy affects the price level (i.e. speed of the transmission process) depends on how quickly prices absorb shocks. Consumer prices are among the stickiest in the economy and absorb shocks gradually, while asset prices are among the most flexible and absorb shocks quickly. Central banks commonly estimate the rate of inflation using a consumer price index, but because consumer prices are sticky, this may cause the policy maker to misjudge the underlying monetary inflation pressure in the short run and pursue the wrong monetary policy. This is one of the reasons why Alchian and Klein (1973), Goodhart (2001) and Bryan et al. (2002) argue that flexible asset prices should be included in the central bank's price index.

When the European Central Bank re-evaluated its monetary policy strategy in 2003, it decided against creating a price index that includes both consumer prices and asset prices (ECB 2003). One practical reason is that asset prices are affected by several non-policy shocks, which, due to asset price flexibility, makes it difficult to extract the monetary inflation rate from these prices. A price index with asset prices is likely to be noisy and informative from a monetary policy perspective.

To overcome this problem, Issing (2003) suggests using the money growth rate as a proxy for the overall monetary inflation rate. Presently, the European Central Bank uses money as a long run consumer price inflation indicator (ECB 2004), but Issing maintains that money growth can also be used as a short run asset inflation indicator. Monitoring money growth can therefore help to estimate the monetary inflation rate both in the short run and the long run.

Several papers have found a long run, but not short run, relationship between money growth and consumer inflation (see e.g. Friedman and Schwarz, 1963; King, 2002; Gerlach, 2004; Neuman and Greiber, 2004; Bruggeman et al., 2005). Furthermore, Christinano et al. (2003), Bordo and Filardo (2004), Detken and Smets (2004) and Gerdesmeier et al. have shown that the lag between monetary policy and consumer inflation has caused policy-driven asset price bubbles.

In this paper we test the relationship between money growth and consumer prices as well as the relationship between financial asset prices (share prices), real asset prices (house prices) and monetary policy over the short and long run to ascertain whether money growth can be used as a short and long run estimate of monetary inflation, as suggested by Issing.

To distinguish between short and long run variations we use Engle's (1974) band spectrum regression, which has been used by Assenmacher-Wesche (2008 a, b) to model consumer inflation. Our analysis also employs a panel data model to improve the precision of (in particular the long run) regression parameter estimates. The panel comprises eight developed countries; Australia, Canada, the Euro Area, Japan, Switzerland, Sweden, the United Kingdom and the United States, and the data cover the period 1977Q4 to 2009Q4.

The results show that there are substantial differences in how quickly different indices respond to monetary shocks. Share prices absorb a shock within six months, but it takes up to a decade for consumer prices to fully absorb a monetary shock. Over the long term money growth has the same effect on all prices, and all prices follow the same long run monetary trend. Overall, our results support Issing's suggestion of using money growth as a short and long run proxy for the underlying monetary inflation rate.

## 2. Empirical Analysis

Two kinds of inflation models are estimated: one for consumer inflation and the GDP deflator

inflation (Model 1), and one for share price inflation and house price inflation (Model 2). Model 1 is based on the quantity equation and is similar to the model used by Assenmacher-Wesche and Gerlach (2008a).

To model inflation we use Engle's (1974) band spectrum regression estimator, which separates different time horizons and estimates one model for each horizon. The estimator is based on a two-step procedure. First, all time series are transformed from the time domain to the frequency domain. In the frequency domain each horizon is represented by a separate set of frequencies, whereby the various time horizons are more easily identified than in the time domain. Second, for each frequency band a separate regression model is estimated. Using a testing procedure, one can thereafter determine how many models are necessary to model the entire spectrum of frequencies. Moreover, the number of time horizons equals the number of models.

The first step of the estimation procedure is oftentimes performed using a Fourier transform, but any transform that yields frequency resolution can be employed. In this paper we use the discrete wavelet transform (DWT) since it has better properties than other transforms when analyzing time series that contain structural breaks, outliers and other non-recurring events (Percival and Walden 2006, Crowley 2007).

To employ the DWT one must choose a set of basis functions. We use the Haar wavelet basis functions, with reference to the length of the data sample and practical implementation problems such as boundary conditions (see Andersson 2008, Percival and Walden 2006)<sup>1</sup>.

The discrete wavelet transform decomposes the data into eight different frequency bands; seven cycles and one trend. The cycles have periodicity of 2 quarters; 1 year; 2 years; 4 years, 8 years and 16 years, respectively. The trend represents 16 years and beyond. We estimate one model for each frequency band and price index. For each price index we then test if there are any statistical differences in the regression results of the frequency bands. Those bands that can be modeled using the same model are combined into representing one time horizon.

Model 1 is specified as,

$$\pi_{it}^f = \alpha_1 m_{it-1}^f + \alpha_2 y_{it-1}^f + \alpha_3 u_{it-1}^f + \alpha_4 g_{it-1}^f + \varepsilon_{it}^f, \quad (1)$$

where  $i$ , denotes the country,  $t$  is time,  $f$  is the frequency band,  $m$  is money growth,  $y$  is real GDP growth,  $u$  is the unemployment rate (which at all frequencies except the low frequency represents an unemployment gap), and  $g$  is the output gap<sup>2</sup>.

Model 2 is specified as,

$$\rho_{it}^f = \beta_1 m_{it-1}^f + \beta_2 y_{it-1}^f + \beta_3 g_{it-1}^f + \beta_4 u_{it-1}^f + \beta_5 il_{it-1}^f + \eta_{it}^f, \quad (2)$$

where  $\rho$  is share price inflation and  $il$  is the long-run government bond yield (10-year bond).

Based on the quantity equation, we expect GDP to have a negative effect in Model 1, but since the rate of the return on assets is likely to be linked to GDP growth, we expect GDP to have a positive effect on asset prices. The asset price model also includes the long-term interest rate to model substitution effects between shares and bonds.

The error term is specified as a two-way fixed effects model,

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<sup>1</sup> We have also tried other wavelet basis functions to test the sensitivity of our results, for example the wavelet functions, Daubechie (4) wavelet and Daubechie (6) wavelet. The regression results are similar when we use the Daubechie wavelets instead of the Haar wavelet, and the parameter estimate for money growth increases slightly for the medium run for consumer price inflation and becomes significant at the 5% level. Furthermore, the unemployment gap tends to become less significant in all inflation models. Otherwise, the results do not significantly change.

<sup>2</sup> The output gap is estimated using the wavelet decomposition of the logged real GDP level.

$$\varepsilon_{it}^f = \begin{cases} v_{it}^f & \text{if } f \neq 0 \\ \lambda_i + f_t + v_{it}^f & f = 0 \end{cases}, \quad (3)$$

where  $\lambda_i$  is an individual specific fixed effect,  $f_t$  a fixed time effect similar for all countries at a given point in time and  $v_{it}^f$  is i.i.d.  $(0, \sigma_{if}^2)$ . The idiosyncratic component can be heteroskedastic both within and between individuals. Models where the error term is heteroskedastic are re-estimated using a GLS. The residuals in equation (2),  $\eta_{if}$ , are assumed to follow a similar one way fixed effects model as in equation (3).

## 2.1 Data

Data for real GDP, consumer prices, GDP deflator, share prices, unemployment rate, long term government bond yield and money is collected from Thomson Financial Data Stream except for the Euro Area. The Euro Area data is mainly collected from the Euro Area Business Cycle Network ([www.eabcn.org](http://www.eabcn.org)) with the exception of share prices, which comes from Datastream. The choice of monetary aggregate is dictated by data availability. In essence we wish to use as broad an aggregate as possible, but different definitions of monetary aggregates make it difficult to compare aggregates between countries. For the United States we use M2, the United Kingdom M4, and all other countries M3. House prices are collected from the Bank of International Settlements (BIS) and are a collection of national house price indices (see Arthur 2005).

All series are logged and we take their first differences such that they represent logged quarterly growth rates, except the long-term government bond yield which is the yearly yield divided by four to represent quarterly rates.

House prices are given on a yearly data frequency, but, since we do not have quarterly data for house prices, we cannot explore cycles with a periodicity up to 1 year. The discrete wavelet transform is unaffected by the difference in data frequency, though.

All frequency components except the zero frequency are per definition stationary (Percival and Walden, 2006). However, the zero frequency (i.e. long run) components may be non-stationary. All our data except the interest rate is in first differences, but we nevertheless test for a unit root in our series. The test is a panel data test by Im et al. (2003) where we allow for serially correlated errors. The null hypothesis is that the series contain a unit root; as can be seen in the Table 1, we reject the null of a unit root for all series at the 5%-significance level.

## 2.2 Regression Results

Regression results are available in Tables 2 to 4. Table 2 shows the result for consumer and GDP-deflator inflation. Table 3 contains the result for share price inflation and Table 4 the result for house price inflation. The tables show that between three (consumer inflation) and six (share inflation) models are necessary to model the entire frequency band. In others words, the data generating process for consumer prices can be divided into three time horizons, and share price inflation into six time horizons. But, for simplicity, let us use consumer inflation to define three horizons: the short run (up to 2 years), medium run (2 to 8 years), and long run (8 years and beyond). Using this definition we have three short-run models for share price inflation, as well as two medium-run models and one long-run model. To increase the number of degrees of freedom, insignificant variables have been removed from the tables. Although we pool data from several countries, the number of degrees of freedom in the long-run models is still limited.

Over the short term none of the considered variables affect consumer inflation, and fluctuations in consumer inflation that last up to two years are either noise or seasonal effects.

Over the medium term, the unemployment gap and the output gap affect consumer inflation, but the effect is relatively small. During the considered period, the business cycle has caused fluctuations in the consumer inflation rate by +/- 0.5 percentage points. Beyond the eight year cycle, neither the unemployment gap nor the output gap influences consumer inflation, but money growth has a significant effect. The parameter estimate is 0.739, which is less than unity as predicted by the quantity equation, but if we exclude the 16-year cycle, the parameter estimate is no longer significantly different from one. The implication of the results is that consumer prices fully absorb a monetary shock after between 8 and 16 years, which means that the transmission process lasts at least a decade.

GDP deflator inflation results are similar to the consumer inflation results, with the main exception that money growth also affects deflator inflation in the short and medium run. However, the parameter estimates are less than unity; short run 0.179, and medium run 0.103. It is only in the long run (8 years and beyond) that the parameter is equal to unity (1.117).

Share prices also respond to short and medium run variations in money growth. For the first 2 quarters the parameter estimate is 0.345. For cycles 6 months or longer (and the trend), we cannot reject that the parameter from money growth is equal to one. In other words, the transmission mechanism is completed after half a year, several years before the consumer and GDP deflator mechanism is completed.

Real GDP growth, as expected, has a positive effect on share prices, both in the medium and long run, but there is no significant short-run effect. Share prices also respond negatively to changes in the bond yield, but only in the short and medium run. A one percentage point increase in the bond yield reduces share prices by between 0.609 and 6.283 percentage points depending on the time horizon. The effect is in general higher in the short run than in the medium run.

House prices are sensitive to business cycle fluctuations, both in the short run and the medium run. Money growth affects house prices in the medium run and the long run; the estimated medium run parameter is 0.350, and the long run parameter 0.751. Removing the 16-year cycle increases the parameter estimate to 0.882 (which is not significantly different from one). Although house prices respond more quickly to money growth than consumer inflation, completing the transmission process takes about a decade, just as for consumer and GDP-deflator inflation.

Over the long term all prices respond one-to-one to money growth and consequently follow the same monetary inflation trend. However, over the short and medium run the price indices respond differently to monetary policy shocks. This difference in the short and medium run response to monetary policy implies that the policy maker can generate temporary relative price changes.

Combining the short and medium run, we find that money growth has generated fluctuations in the share price inflation rate of the magnitude +/- 7 percentage points around the long-run trend. To translate into price level effects, assume all price indices are equal to 1 in 1999Q4 (this allows us to illustrate the effect of monetary policy during the last decade). From 2000Q1 until 2008Q3 (outbreak of the financial crisis), the share price level in the United States increased by 6% above the general long-term inflation trend shared by all price indices. In the Euro Area share prices were 9.3% above the long-run value, and in the United Kingdom 8.1% above the trend.

Due to the data frequency we cannot explore short-run house prices, but monetary policy has generated medium-run fluctuations in house inflation of the size +/- 0.7 percentage points. Setting all price indexes to 1 in 1999Q4, house prices were some 1% to 2% above the long-run monetary inflation trend by 2008Q3.

In total, share inflation fluctuates by +/- 40 percent over the short to medium run and house inflation by 3%. The effect of monetary policy is only a smaller fraction of the total

variation in these inflation rates, which illustrates the difficulty of including asset prices in a monetary price index. However, our results also show that money growth affects some prices at all time horizons, and hence it can be used as a proxy for the overall monetary inflation rate as suggested by Issing (2003).

### **3. Conclusions**

Monetary policy affects all prices in the economy. Some prices absorb money shocks quickly, while others do so slowly. It is difficult to extract the monetary inflation signal from flexible and volatile prices such as asset prices, and central banks therefore use sticky consumer prices to measure inflation. However, using sticky prices to measure inflation may cause the policy maker to misjudge the true rate of policy-induced inflation. To overcome this problem, Issing (2003) suggested using the monetary growth rate as a proxy for policy induced inflation rate.

In this paper we have shown that money growth is indeed related to inflation at all time horizons and that money growth can be used as a short, medium and long run indicator of inflation. We have also shown that share prices fully absorb monetary shocks within half a year, while house prices, consumer prices and the GDP deflator first absorb these shocks after a decade. Considering the long lag between policy and inflation, using the money growth rate as an inflation indicator can hence be beneficial for the policy maker.

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Variable	Test Statistic	P-Value
Consumer Price Inflation	-2.468	0.007
GDP Deflator Inflation	-1.729	0.042
Consumer Food Price Inflation	-4.088	0.000
House Price Inflation	-4.844	0.000
Share Price Inflation	-6.421	0.000
Money Growth	-5.522	0.000
Real GDP Growth	-2.883	0.002
Unemployment	-3.801	0.000
Output Gap	-9.251	0.000
Long Term Interest Rate	-0.972	0.166
Long Term Interest Rate (excluding Japan)	-2.160	0.039

*Table 1: Unit Root Tests*

	Short Run <2 years	Medium Run 2 years – 8 years	Long Run >8 years	Long Run >16 years	Short Run <2 quarters	Short Run 2 quarters – 2 years	Medium Run 2 years – 8 years	Long Run >8 years	Long Run >16 years
	<i>Consumer Price Inflation</i>				<i>GDP Deflator Inflation</i>				
Money Growth	---	---	0.739*** (0.033)	1.206*** (0.250)	---	0.179*** (0.050)	0.103*** (0.013)	1.117*** (0.069)	0.985*** (0.044)
Real GDP Growth	---	---	---	-1.613*** (0.142)	---	---	---	---	-1.487*** (0.208)
Unemployment Rate	---	-0.107*** (0.019)	---	---	---	---	-0.171*** (0.043)	---	---
Output Gap	---	0.112** (0.012)	---	---	---	---	---	---	---
<i>Degrees of Freedom</i>	---	94	30	14	---	381	94	31	14
<i>Adjusted R<sup>2</sup></i>	---	0.481	0.798	0.652	---	0.351	0.225	0.594	0.617

*Table 2: Consumer Price Inflation and GDP Deflator Inflation*

	Short Run 2 quarters	Short Run 2 quarters- 1 year	Short Run 1 year – 2 years	Medium Run 2 years – 4 years	Medium Run 4 years – 8 years	Long Run >8 years	Long Run >16 years
Money	0.346*** (0.131)	1.083*** (0.335)	0.983*** (0.205)	1.054*** (0.104)	1.003*** (0.076)	1.308*** (0.192)	1.049** (0.538)
Real GDP	---	---		2.852*** (0.035)	3.343*** (0.126)	3.791*** (0.377)	0.562*** (0.196)
Unemployment (gap)	---	---		---	---	---	---
Output Gap	---	0.590** (0.351)	0.350*** (0.150)	---	---	---	---
Long Term Interest Rate	-1.642*** (0.238)	-3.184*** (0.592)	-6.283*** (0.254)	-0.609*** (0.130)	-1.279*** (0.545)	---	---
<i>Degrees of Freedom</i>	510	253	125	61	29	30	14
<i>R<sup>2</sup></i>	0.051	0.097	0.083	0.128	0.272	0.588	0.877

*Table 3: Share Price Inflation*

	Short Run 1 year – 2 years	Medium Run 2 years – 8 years	Long Run >8 years	Long Run >16 years
Money	---	0.350*** (0.092)	0.751*** (0.013)	0.882*** (0.134)
Real GDP	---	0.452** (0.272)	0.297*** (0.046)	0.685*** (0.124)
Unemployment (gap)	-0.259*** (0.040)	---	---	---
Output gap	---	0.142*** (0.059)	---	---
Long Term Interest Rate	---	---	---	---
<i>Degrees of Freedom</i>	127	93	30	14
$R^2$	0.196	0.374	0.842	0.912

Table 4: House Price Inflation