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Robert-Paul Berben

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Does stock market uncertainty impair the use of monetary indicators in the euro area?

Monetary indicators and the stock market in the euro area

Abstract

The relationship between monetary indicators and inflation is usually assumed to be linear, implying that looser monetary conditions always signal an increase in inflation. Recently, money growth in the euro area surged while inflation remained comparatively subdued. This seems at variance with linearity. At the same time, stock market uncertainty peaked, suggesting that part of the money growth resulted from portfolio adjustment and was hence non-inflationary. We employ a threshold regression model to verify the claim that the impact of monetary indicators on future inflation varies conditional on stock price volatility. We show that there is limited evidence to support this claim. On the other hand, our results indicate that stock market data may contain useful information regarding future inflation.

1 Introduction

It is a widely held view that, in the long-run, the money stock and the price level are tightly linked (see Issing *et al.* (2001) for a recent account). Whether money also contains useful information regarding future inflation in the short- to medium-run, is an issue that is still open to debate. For the United States the empirical evidence seems mostly unresponsive. For example, Stock and Watson (1999) argue that adding money supply to a Phillips curve model in some cases leads to better inflation forecasts, while Estrella and Mishkin (1997) conclude that, due to recurrent velocity shocks, money does not perform well as an information variable for monetary policy. As for the euro area, empirical evidence produced in recent years is more affirmative. It seems that there is both a stable money demand relationship¹ and that monetary aggregates provide significant and independent information for future price developments in the euro area, especially at medium term horizons (Nicoletti Altissimi, 2001).

In practice, extracting information regarding future inflation from money growth figures entails a considerable amount of judgement. Plain money growth rates are often contaminated by temporary factors, limiting their information content with respect to future inflation. Recent experiences in the euro area are a case in point. Since the beginning of 2001, the growth rate of M3 has picked up significantly, exceeding the ECB's reference value of 4.5% starting May 2001. Yet, price developments have remained relatively sub-

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dued. A popular explanation for these apparently inconsistent developments is that, at that time, buoyant money growth was to a sizeable extent driven by events in the stock market, and for that reason did not signal a pick up in inflation. Following the slide in global stock markets and the related rise in stock price volatility, investors moved part of their assets from the stock market to short-term interest rate bearing securities which are included in M3. According to the ECB,

The build-up of liquidity reflected in these data occurred in an economic and financial environment characterised by relatively high uncertainty and should therefore only be temporary. In this respect, the high growth in M3 should not be seen as signalling upward risks to price stability thus far (Editorial, ECB Monthly Bulletin February 2002).

In assessing the implications of money growth for future inflation it is important to gauge the extent to which the additional money balances are held for transaction purposes. This is difficult, since economic agents obviously do not earmark their money holdings to various motives. The above example suggests a (partial) solution to this problem. When the stock market is calm, stock price volatility basically does not matter for money demand², and high money growth is generally associated with a rise in future inflation. But, when the stock market is very turbulent, money holdings may be pushed up temporarily due to portfolio reallocation by investors. As a result, the link between money

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4 holdings and future inflation may weaken. Put differently, the level of stock price volatil-
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7 ity can be used to discriminate between periods in which changes in money holdings are
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10 more tightly linked to the transaction motive - and hence future inflation -, and periods in
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13 which this link is less tight. This non-linear feature of the relationship between money and
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16 future inflation has largely been overlooked in previous research. The main contribution of
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19 the present paper is that it formally analyses this non-linear relationship between money,
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22 inflation, and stock price volatility within the context of the threshold regression model
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25 (Hansen, 1996, 2000). In particular, we test the hypothesis that the link between money
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28 growth and inflation breaks down when stock price volatility exceeds a certain threshold
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31 level, and subsequently estimate this threshold level from the data. In addition to plain
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34 money growth, we also assess the information content of three monetary indicators that
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37 are regularly monitored by the ECB, namely money overhang, the real money gap, and
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40 p-star (see Klöckers, 2001), taking these possible nonlinearities explicitly into account.

41
42 The remainder of the paper is organised as follows. In the next section, we briefly
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45 survey the recent literature on the interaction between money, inflation, and asset markets.
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48 Section 3 introduces the data. Section 4 discusses some econometric issues. Section 5
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51 contains the empirical results. Section 6 concludes.

2 Money, inflation, and the stock market

The literature on the interaction between money, inflation and asset markets is voluminous; see Sellin (2001) for a recent survey. In this section, we discuss a number of recent contributions and motivate the research question of the present paper.

In analysing the interaction between money, inflation and asset markets, most papers take the monetary portfolio model as point of departure. This model views money as an asset among other assets in investors portfolios. By implication, demand for money not only depends on the rate of return on holding money balances, but also on the returns of alternative assets, and their respective variances and covariances³. Along these lines, Carpenter and Lange (2002) argue that as in the US the stock market has become a significant source of household wealth, it seems plausible that variations in equity prices could affect money demand. They therefore re-specify an - in other aspects - standard US money demand function to include stock market volatility and revisions to analysts earnings projections. The authors find that both equity market variables enter the money demand function in a statistically significant way and that forecasts of money growth can be improved by adding these variables. Cassola and Morana (2002) analyse the interaction between monetary policy and the stock market in a small scale structural vector error correction model for the euro area. In this model the long run money demand is not only a function of the spread between, respectively, the short-term and long-term interest

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4 rate, and the own rate of return on M3, but of the real stock price as well. Furthermore,
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7 following Gordon's growth model, developments in the stock market are related to changes
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10 in output. The authors show that these modelling assumptions are indeed supported
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13 by the data. Furthermore, they demonstrate that in their model stock prices play an
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16 important role in the monetary transmission mechanism in the euro area, but that there is
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19 no evidence on a direct impact of stock prices on inflation. Kontolemis (2002) shows that
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22 although stock prices are important in explaining short-run movements in M3 in the euro
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25 area, they are not important for the long-run determination of money demand. While,
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28 on the basis of these results, the author questions the usefulness of a reference value for
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31 M3 growth in the euro area, he does not rigorously explore the implications of his results
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34 for the quality of inflation forecasts based on monetary indicators. Finally, Bruggeman *et*
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37 *al.* (2003) conclude that the use of real stock prices may improve forecasts of money and
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40 inflation in the euro area, but on the other hand stock price volatility seems to contain
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43 little information in this respect.

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45 This review of the literature suggests, first, that the evidence supporting a relationship
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48 between the asset market developments and money demand is mixed, and second, that the
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51 impact of asset market developments on information content of money for future inflation
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54 is an issue that has been largely neglected.

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57 In addressing these two issues, we question one of the key elements of the monetary
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4 portfolio model, in particular the assumption that at any point in time, the demand for
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7 money depends on the returns of all alternative assets, and their respective variances
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10 and covariances. We think that although this assumption is tenable for close - low risk
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13 - substitutes to money holdings (such as government bonds), it is less convincing that
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16 investors weigh their holdings of money against (high risk) stocks on a continuous basis.

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18 We conjecture that developments in the stock market - in the present paper we focus on
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21 stock price volatility - only impinge on money balances when the outlook for the stock
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24 market changes *substantially*. Research on optimal trading strategies shows that in the
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27 face of transaction costs a steady strategy of buying and holding a diversified portfolio
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30 is optimal. For instance, Liu and Loewenstein (2002) show that, while the optimal share
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33 of stocks in a portfolio comprising both stocks and bonds is decreasing in stock return
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36 volatility, the optimal transaction policy is to maintain the ratio of stocks to bonds within
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39 a wedge, represented by a buy boundary and a sell boundary. Put differently, only in case
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42 the outlook for stocks deteriorates sharply, investors are likely to scale back their stock
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45 holdings. Money holdings may then act as a buffer, cf. Milbourne (1987). But even if
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48 stock price volatility displays a temporary hike only - leaving the intrinsic risk of holding
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51 stock unchanged - investors may decide to sell off stocks. Drawing on research into the
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54 influence of visceral factors on economic behaviour, Loewenstein (2000) argues that fear
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57 tends to increase over time as a particular risk becomes temporally imminent, even when
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4 cognitive appraisals of risk remain unchanged. Furthermore, Sonsino *et al.* (2002) present
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7 experimental evidence suggesting that economic agents dislike complexity in choice with
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10 uncertainty. This means that as soon as it is patently obvious that the outlook for the
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13 stock market has turned for the worse will economic agents move part of their assets from
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16 the stock market to money balances. Until that situation has arisen, agents may feel that
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19 they have little competence in evaluating the efficiency of their portfolio (see Barberis and
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22 Thaler, 2002, and the references therein).

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25 All in all, the relationship between money growth and future inflation is likely to depend
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28 on stock price volatility in a nonlinear way. When the stock market is calm, stock price
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31 volatility basically does not matter for money demand, and high money growth is generally
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34 associated with a rise in future inflation. But, when the stock market is very turbulent,
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37 money holdings may be pushed up temporarily due to portfolio reallocation by investors.
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40 As a result, the link between money holdings and future inflation may weaken.

41 **3 The Data**

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46 Our dataset comprises quarterly observations for the euro area on the growth rate of
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49 M3, HICP inflation, stock price volatility, and three monetary indicators, namely money
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52 overhang, the change in P-star, and the real money gap. The dataset spans the period
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55 from 1980Q1 to 2003Q1. P-star is defined as the long-run equilibrium price level that is
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58 implied by the current money stock, provided that output is at potential. Throughout
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4 the paper, we calculate potential output using a standard HP filter. The real money gap
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7 measures the deviation of real money balances from their long-run equilibrium level. In
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10 calculating these indicators, opportunity costs (ie. velocity) are evaluated at their current
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13 levels. In this way, we avoid that the indicators are affected by temporary effects on the
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16 current money stock of variations in the opportunity costs of holding money. Changes
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19 in monetary aggregates induced by portfolio shifts are likely to have little implications
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22 for future price developments (provided, of course, that there is no shift from portfolio
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25 to transaction balances). By correcting for portfolio re-allocation effects - in this case
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28 changes in the costs of close substitutes - we may thus improve our forecasts of future
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31 inflation based on monetary indicators. Finally, money overhang is the difference between
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34 the current real money stock and the long-run equilibrium real money stock evaluated at
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37 current output and opportunity costs. The data have been obtained from several sources;
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40 details are provided in the Appendix.

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42 It is common practice to measure stock price volatility in a specific quarter by the
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45 sample variance of stock returns within that period. Andersen and Bollerslev (1998) show
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48 that the quality of this estimate can be improved by computing the variance over finer
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51 subperiods, since this preserves the unbiasedness of the estimate while making it less
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54 erratic. We thus calculate stock price volatility in any quarter as the sample variance
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57 of daily stock returns within that quarter. Actually, we use the log of realised (within
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4 each quarter) stock price volatility. Andersen *et al.* (2001) show that realised volatility
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7 has certain attractive properties, including that of stationarity. Stationarity is an essential
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10 prerequisite for the threshold model's asymptotic distribution theory - which we will discuss
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13 in the next section - to prevail.

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16 In order to construct the three monetary indicators we use a money demand equation
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19 following the Brand and Cassola (2000) specification, which implies a long-run equilibrium
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22 of the form:

$$m_t = c_0 + c_1 y_t + c_2 i_t, \quad (1)$$

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28 where m_t , y_t , and i_t denote real money balances, real GDP, and the long-term interest
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31 rate, respectively. We use Dynamic OLS to recover point estimates of c_1 and c_2 . The
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34 point estimates appear to be fairly insensitive to the number of leads-and-lags included in
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37 estimation and across sub-samples⁴.

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40 To get an idea of the sample properties, we present some stylised facts. Figure 1
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43 graphically displays the data. Inflation, the change in p^* , and money growth are quarter-
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46 on-quarter changes in the HICP, p^* , and M3, respectively, at an annual rate. Money
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49 overhang and the real money gap are presented as percentage deviations from their re-
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52 spective sample averages. The graphs show that during the years 1980-1985 the decrease
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55 in inflation was - to some extent - matched by a slowdown in money growth and a fall
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58 in money overhang and the real money gap. Meanwhile, stock price volatility was com-
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4 paratively low. On the other hand, from 2000 onwards money overhang, the real money
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7 gap and - to a lesser extent - money growth accelerated sharply, while stock price volatil-
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10 ity was relatively high and inflationary pressures were limited. This provides some first
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13 preliminary evidence for a nonlinear relationship between monetary indicators and future
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16 inflation, conditional on stock price volatility.

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19 To gain some further insight, Table 1 shows a number of sample statistics, both for
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22 the full sample and for those observations for which stock price volatility is either above
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25 or below its 75% quantile. In general, the correlations between inflation and the mon-
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28 etary indicators are lower when stock price volatility exceeds its 75% quantile. Table 1
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31 thus provides further tentative evidence for a nonlinear relationship between inflation and
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34 monetary indicators. Note, however, that the sample split has been made exogenously.
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37 Futhermore, it is not obvious that the correlations presented in Table 1 differ significantly
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40 across regimes. The threshold regression model, which we will use in the sequel of this
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43 paper, can handle these issues more formally.

45 **4 Econometric Issues**

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49 In this section, we give a short summary of issues surrounding estimation and inference in
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52 the threshold regression model. The threshold regression model has been used, inter alia,
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55 to investigate cross-country growth rates (Durlauf and Johnson, 1995), the inflation-growth
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58 nexus (Tsionas and Christopoulos, 2003), the relationship between financial development
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and economic growth (Deidda and Fattouh, 2002), and the relationship between income inequality and economic development (Savvides and Stengos, 2000). The standard threshold regression model can be represented as follows⁵:

$$y_t = \beta_1 x_t + e_t, \quad q_t \leq \gamma, \quad (2)$$

$$y_t = \beta_2 x_t + e_t, \quad q_t > \gamma, \quad (3)$$

where q_t is called the threshold variable, which is used to split the sample into two regimes, depending on whether q_t exceeds the threshold value, γ , or not. e_t is a random regression error, $t = 1, \dots, n$. As explained in more detail in Hansen (2000), a natural estimator of the parameters $\{\beta_1, \beta_2, \gamma\}$ of the threshold regression model is least squares [LS], ie. minimising the sum of squared errors function $\sum_t e_t^2$. These LS estimates will be denoted $\hat{\beta}_1$, $\hat{\beta}_2$, and $\hat{\gamma}$, respectively. One way to simplify the estimation problem is to note that for known γ , the conditional (on γ) sum of squared errors is minimised by doing LS estimation on both subsamples. For unknown γ , the sum of squared errors is minimised by minimising this conditional sum of squared errors with respect to γ . For this minimisation, γ is assumed to be restricted to a bounded set Γ . We take $\Gamma = [q_{[(0.1*n)]}, q_{[(0.9*n)]]]$, where $[\cdot]$ denotes integer part and $q_{(0)}, \dots, q_{(n)}$ denote the order statistics of the threshold variable q_t , such that $q_{(0)} \leq \dots \leq q_{(n)}$. Forcing each regime to contain at least 10% of the data is common practice.

Although the slope parameters $\hat{\beta}_1$ and $\hat{\beta}_2$ are asymptotically Gaussian distributed (as

if γ were fixed and known with certainty), in finite samples it is recommended to take the sampling uncertainty of $\hat{\gamma}$ - which can be fairly large - into account, cf. Hansen (2000).

This is done by constructing pointwise confidence intervals for the slope parameters for various values of γ , such that γ is in a confidence interval around $\hat{\gamma}$ with prespecified coverage. The union of these pointwise confidence intervals is then used as a confidence interval for the slope parameters⁶. The sample distribution of $\hat{\gamma}$ itself is non-standard, even asymptotically, and must be obtained by simulation as discussed in Hansen (1996).

5 Empirical results

In this section we discuss our empirical results and examine whether the relationship between monetary indicators and inflation changes conditional on stock price volatility exceeding a certain threshold value⁷.

We assess the performance of monetary indicators in predicting future inflation using the following bivariate model⁸,

$$\pi_{t+h}^h = \alpha_1 + \delta(L)\pi_t + \beta_1 x_t + e_t, \quad q_t \leq \gamma, \quad (4)$$

$$\pi_{t+h}^h = \alpha_2 + \delta(L)\pi_t + \beta_2 x_t + e_t, \quad q_t > \gamma, \quad (5)$$

where $\pi_t^h = (4/h) \ln(P_t/P_{t-h})$ is the annualised h -period inflation in the HICP (P_t). $\pi_t = 4 \cdot \ln(P_t/P_{t-1})$ is the quarterly inflation at an annual rate. x_t is a monetary indicator whose forecasting performance is to be evaluated. $\delta(L)$ is a polynomial in the lag operator L and h denotes the forecast horizon (we consider $h = 1, 2, 4, 6$, and 8). q_t is stock price

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4 volatility and γ is a fixed threshold value. We impose $\delta(L)$ to be equal across both regimes,
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7 so that inflation persistence is assumed not to be affected by q_t . This allows us to isolate
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10 the impact of stock price volatility on the predictive content of the monetary indicators.
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13 Note that we allow the intercept to differ across regimes. For a number of reasons, stock
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16 price volatility may be directly related to (future) inflation. For instance, Campbell *et*
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19 *al.* (2001), citing work by Lilien (1982), reason that stock market volatility is related to
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22 structural change in the economy. Structural change consumes resources, which depressed
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25 GDP growth. This - in turn - exerts a downward pressure on inflation. In fact, Guo (2002)
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28 shows for the US that stock price volatility tends to move countercyclically, exhibiting
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31 spikes during recessions. By implication, future inflation will then - *ceteris paribus* - on
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34 average be higher if $q_t > \gamma$. If we restrict the intercept to be equal across regimes, β_2 may,
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37 in part, reflect this autonomous impact of high volatility on future inflation. Therefore,
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40 we start off with a model which allows both the intercept and the slope parameter to differ
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43 across regimes. Next, we also consider a model which only allows the slope parameter
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46 to change conditionally on stock price volatility. This permits us to more accurately
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49 gauge the impact of the monetary indicators on the evidence of a two-regime split in our
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52 sample. Finally, on a more practical note, following the Frisch-Waugh-Lovell theorem⁹,
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55 we implement the cross-equation restriction on $\delta(L)$ by first performing partial regressions
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58 of π_{t+h}^h and x_t , respectively, on $\delta(L)\pi_t$ ¹⁰. We then continue with the residuals we obtain
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4 from these regressions.
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7 Table 2 presents estimates of β for the full sample, ie. without the threshold effect.
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9 Generally speaking, these estimates concur with results found elsewhere in the literature.
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11 In the short run, monetary indicators appear unrelated to future inflation. But over longer
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13 horizons, some monetary indicators, in our case money overhang and the real money gap,
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16 tend to lead inflation significantly (at 10% significance level).
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21 Before we turn to estimating the threshold regression model in equations (2) and (3),
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23 we first make sure that the presence of two volatility regimes is supported by the data. This
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25 can be done by an F-test of the null hypothesis $\beta_1 = \beta_2$. Since the threshold parameter is
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27 not identified under the null hypothesis (when $\beta_1 = \beta_2$, γ can take on any value without
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29 changing the fit of the model), this F-test has a non-standard limiting distribution. As
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31 before, appropriate p-values for this F-test can be obtained by simulation, cf. Hansen
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33 (1996). The results for the four monetary indicators, respectively, are presented in Table
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42 3. Asymptotic p-values are given in parentheses. Over short horizons, there is little
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44 evidence of a two-regime split of our sample. To some extent this was to be expected, since
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46 the monetary indicators that we use as explanatory variables are known to contain little
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48 information on short-term inflation dynamics. On the other hand, over longer horizons the
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50 presence of a low and a high volatility regime is supported by the data. The evidence in
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56
57 Table 3 clearly lends support to our proposition that the relationship between inflation and
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4 money (monetary indicators) is non-linear, and changes conditional on the stock market
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7 being either calm or turbulent.
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10 Moving on to estimation of the threshold regression models, Table 5 present estimates
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12 of the threshold regression model (4)-(5) for the cases in which the F-test supports the
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14 presence of two regimes at at least the 90% level¹¹. It appears that in most cases the
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16 presence of two regimes stems completely from differences in the intercept and is in fact
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18 unrelated to changes in the information content of the monetary indicators. Often β_1 and
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20 β_2 hardly differ, while α_1 and α_2 differ by a fairly large amount. Indeed, if we put α_1 equal
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22 to α_2 and re-run the F-tests in Table 3, we can only significantly reject the linear model
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24 for the real money gap.
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33 As a further illustration of the extent to which the relationship between future inflation
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35 and monetary indicators depends on stock price volatility, Figure 2 plots future inflation
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37 (eight quarters ahead) against the real money gap. Clearly, the upward sloping relationship
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39 that prevails in the low volatility sample (panel (b)) is masked in the full sample (panel
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41 (a)) due to the absence of any relationship between inflation and the real money gap when
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43 stock price volatility is high (panel (c)).
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50 Where do these results leave us? First, the paper shows that facing an increase in money
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52 growth (or any other monetary indicator), the outlook for price stability deteriorates less in
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54 a situation of high stock price volatility compared to a situation of low stock price volatility.
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4 Although the statistical evidence is weak, this lends some credit to the hypothesis we
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7 advanced in Section 2. Second, keeping the level of the monetary indicator fixed, a switch
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10 to a situation of high stock price volatility elicits a substantial upwards revision of future
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13 inflation. This confirms that stock price volatility tends to move countercyclically. Taken
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16 together, these two lines of reasoning imply that the impact of an increase in money growth
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19 (or any other monetary indicator) *as a result of* an increase in stock price volatility has -
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22 in principle - an ambiguous effect on future inflation.
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24 **6 Concluding remarks**

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28 The actual inflation rate and measures of inflationary pressure extracted from monetary
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31 indicators may move in opposite directions from time to time. An explanation for this phe-
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34 nomenon that has recently been put forward is that high money growth may temporarily
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37 to a sizeable extent be driven by events in the stock market, and for that reason not lead
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40 a pick up in inflation.
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43 The present paper confirms that the interaction between monetary indicators, future
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46 inflation and stock price volatility is complex. It shows that the impact of an increase in
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49 money growth (or any other monetary indicator) *as a result of* an increase in stock price
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52 volatility has - in principle - an ambiguous effect on future inflation. In terms of central
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55 bank communication this means that, although there is some weak evidence indicating that
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58 developments in the stock market can be used to quantify inflationary pressure arising from
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4 monetary indicators, it is of paramount importance to take the information content of the
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7 stock market for future inflation into account as well.
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9 10 **A Data sources**

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13 We have taken a historical series on the monthly end-of-period stock of M3 in the euro
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16 area from the ECB website. This series contains two obvious breaks: German unification
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19 in 1991, and EMU accession by Greece in 2001. We have remedied these jumps in the
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22 growth rate of M3 as follows. First, we have incremented the series prior to German
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25 unification with a fixed amount equal to the whole German contribution to M3 at the time
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28 of unification multiplied by the share of East-German GDP in the whole German GDP.
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30
31 Second, from 2001 onwards, we have lowered euro area M3 by a fixed amount equal to the
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33
34 Greek contribution to M3 in december 2000. This monthly series runs from January 1980
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37 to March 2003. Observations at the quarterly frequency have been computed as quarterly
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39
40 averages of this monthly series.
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43 Series on euro area HICP, GDP, and the long-term interest rate, are taken from the
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46 Area Wide Model database (Fagan *et al.*, 2001) for the period from 1980Q1-2000Q4 and
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48
49 from the ECB's Monthly Bulletin for the period 2001Q1-2003Q1.
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52 Series of daily observations of a euro area stock price index are obtained through
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55 Datastream.
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Notes

¹Examples are Brand and Cassola (2000), Calza *et al.* (2001), Coenen and Vega (1999), and Kontolemis (2002)

²We will elaborate on this in Section 2.

³An early paper exploring this idea empirically is Slovin and Sushka (1983). They analyse the demand for money in the US, and are able to show that an increase in volatility of bond returns leads to an increase in the demand for money. Choi and Oh (2003) show that output uncertainty and monetary uncertainty as well as output, interest rates, and financial innovations affect money demand.

⁴Results are available upon request.

⁵In view of the theoretical considerations in Section 2, we allow for two regimes at the most.

⁶Hansen (2000) shows - using simulation - that to obtain a nominal 95% confidence interval for $\hat{\beta}_1$ and $\hat{\beta}_2$ selecting pointwise confidence intervals for various values of γ contained in a 80% confidence interval around $\hat{\gamma}$ appears to work reasonably well.

⁷Parameter estimates and test statistics have been computed with the GAUSS code obtained from Hansen's web homepage.

⁸We only consider in-sample forecasting of future inflation. Conducting an out-of-sample forecasting exercise is complicated by the fact that a considerable number of 'high-volatility'-observations cluster round the end of the sample.

⁹See Davidson and MacKinnon (1993, p19).

¹⁰The order of the lag polynomial is, on the basis of various information criteria, fixed at four. Details are available upon request.

¹¹For expositional reasons, both the estimates of α_1 and α_2 , and their respective standard errors, have been multiplied by 1000.

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Table 1: Some sample statistics

	Inflation	Money growth	Money overhang	Real money gap	Change in p^*	Stock price volatility
Full sample						
mean	3.88	6.43	0.00	0.00	3.98	-0.08
correlation with inflation		0.55	0.28	0.21	0.62	-0.35
Stock price volatility above 75% quantile						
mean	2.15	5.86	0.03	0.07	2.65	0.38
correlation with inflation		0.03	0.08	0.26	0.16	-0.42
Stock price volatility below 75% quantile						
mean	4.46	6.62	-0.01	-0.02	4.43	-0.23
correlation with inflation		0.63	0.48	0.42	0.67	-0.06

Table 2: Benchmark linear model¹

h	money overhang			real money gap			Δp^*		money growth			
	β	R^2	β	R^2	β	R^2	β	R^2	β	R^2		
1	0.22	(0.09)	0.07	0.26	(0.08)	0.11	0.00	(0.18)	0.00	0.02	(0.07)	0.00
2	0.29	(0.07)	0.17	0.32	(0.06)	0.22	0.18	(0.14)	0.02	0.05	(0.05)	0.01
4	0.31	(0.06)	0.24	0.32	(0.05)	0.31	0.18	(0.12)	0.03	0.08	(0.04)	0.04
6	0.39	(0.07)	0.29	0.40	(0.06)	0.39	0.25	(0.12)	0.05	0.10	(0.04)	0.06
8	0.35	(0.07)	0.24	0.37	(0.06)	0.32	0.26	(0.12)	0.05	0.12	(0.04)	0.09

¹ Asymptotic p-values are in parentheses.

Table 3: F-test for regime switching, $\alpha_1 = \alpha_2$ and $\beta_1 = \beta_2$ ¹

indicator	$h = 1$	$h = 2$	$h = 4$	$h = 6$	$h = 8$					
money overhang	3.30	(0.87)	11.45	(0.08)	8.26	(0.24)	11.19	(0.08)	14.03	(0.03)
real money gap	3.27	(0.87)	5.11	(0.59)	8.28	(0.22)	11.45	(0.08)	16.19	(0.01)
Δp^*	3.00	(0.91)	7.07	(0.36)	6.69	(0.37)	9.34	(0.16)	11.14	(0.09)
money growth	4.44	(0.70)	7.07	(0.37)	6.10	(0.44)	9.08	(0.16)	10.58	(0.09)

¹ Asymptotic p-values are in parentheses.

Table 4: F-test for regime switching, $\beta_1 = \beta_2$ given $\alpha_1 = \alpha_2$ ¹

indicator	$h = 1$	$h = 2$	$h = 4$	$h = 6$	$h = 8$					
money overhang	2.77	(0.59)	5.92	(0.17)	2.17	(0.74)	1.52	(0.91)	3.62	(0.49)
real money gap	1.53	(0.83)	2.26	(0.73)	4.56	(0.32)	6.10	(0.16)	9.96	(0.04)
Δp^*	2.18	(0.71)	1.67	(0.88)	3.96	(0.39)	3.33	(0.50)	4.58	(0.31)
money growth	4.26	(0.39)	5.24	(0.26)	3.38	(0.52)	4.48	(0.34)	4.90	(0.31)

¹ Asymptotic p-values are in parentheses.

Table 5: Estimates of threshold models¹

indicator	h	α_1	β_1	α_2	β_2	$\hat{\gamma}$	n_L	n_H				
money overhang	2	-0.17	(0.97)	0.40	(0.08)	4.14	(1.84)	-0.02	(0.12)	0.154	68	19
	6	-0.25	(0.79)	0.40	(0.07)	4.85	(1.46)	0.41	(0.14)	0.064	62	21
	8	-0.45	(0.81)	0.38	(0.07)	5.34	(1.57)	0.36	(0.15)	0.064	61	20
real money gap	6	0.56	(0.76)	0.49	(0.07)	3.18	(1.25)	0.21	(0.09)	0.064	62	21
	8	0.49	(0.80)	0.50	(0.07)	3.20	(1.21)	0.15	(0.09)	-0.015	58	23
Δp^*	8	-1.11	(0.92)	0.44	(0.14)	3.19	(1.51)	-0.03	(0.20)	0.001	59	22
money growth	8	-1.02	(0.85)	0.14	(0.05)	5.01	(1.79)	0.08	(0.07)	0.155	66	15

¹ Asymptotic p-values are in parentheses. n_L and n_H denote the number of observations in the low and high volatility regime, respectively. For expositional reasons, both the estimates of α_1 and α_2 , and their respective standard errors, have been multiplied by 1000.

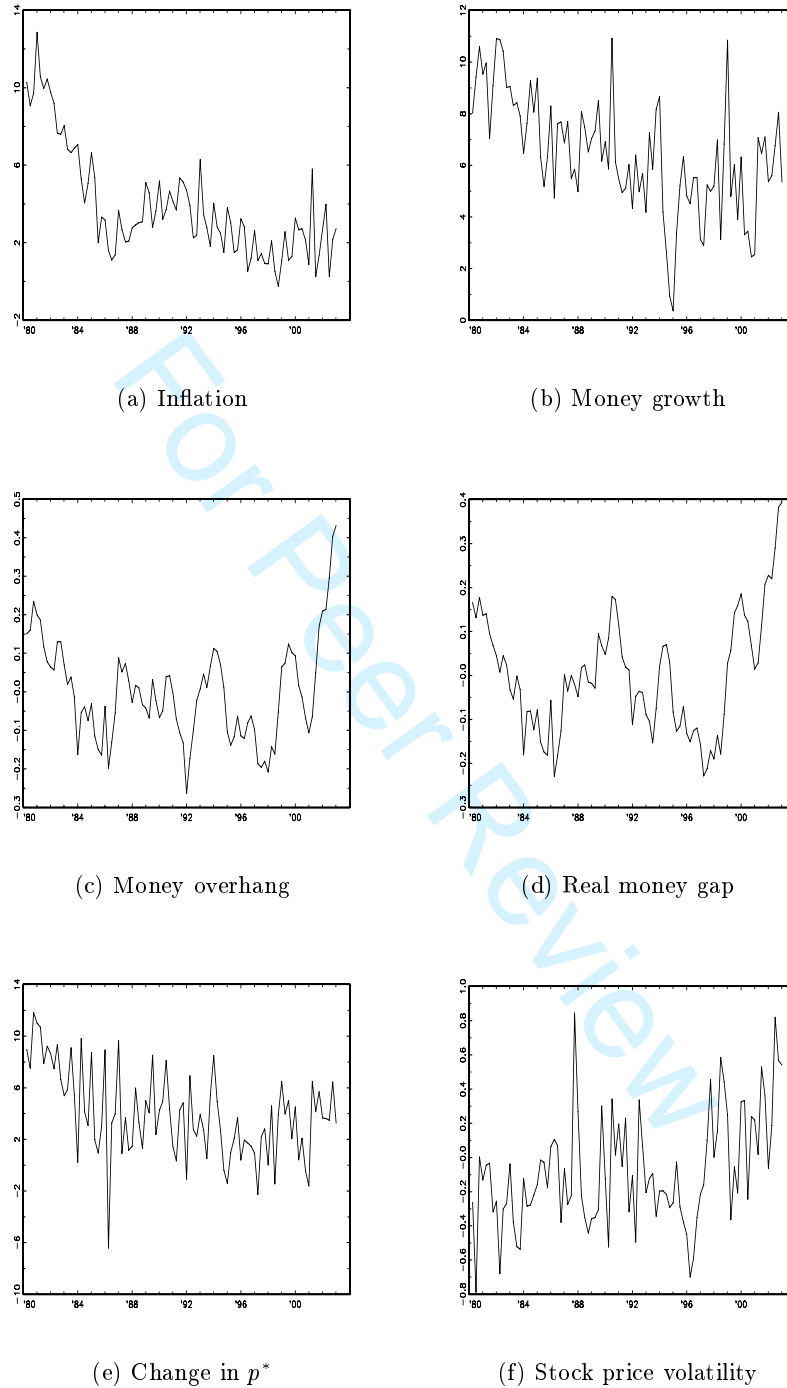
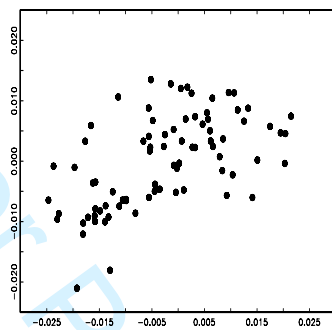
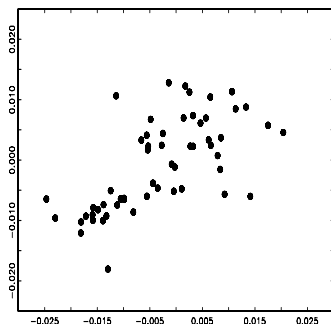


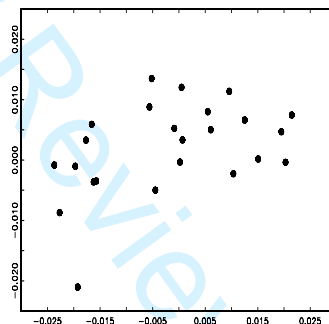
Figure 1: The Data



(a) Full sample



(b) Low volatility



(c) High volatility

Figure 2: Future inflation versus the real money gap (conditional on lagged inflation)