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Is the relationship between inflation and its volatility asymmetric? US evidence, 1800–2016

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A B S T R A C T

This paper investigates the relationship between inflation and inflation volatility. Using annual data from 1800 to 2016, the results show that US inflation and its volatility have been positively correlated when inflation exceeds a certain value, but negatively correlated when inflation is below this threshold. The evidence also suggests that the break in the relationship occurs between annual inflation rates of 0.8% and 4.3%, which includes both the 2% inflation target of many central banks and the 3.5% break point predicted by the New Keynesian model of Coibion, Gorodnichenko, and Wieland (2012).

1. Introduction

There is widespread consensus in macroeconomics that the level of inflation and inflation volatility are strongly and positively correlated. Originally, the positive relationship was considered mostly at higher inflation rates, as in Friedman (1977). Gradually, however, the positive correlation was extended to apply to moderate or even low inflation rates (for example, Taylor, 1981; Ball & Cecchetti, 1990; Brunner & Hess, 1993; Grier & Perry, 1998; Davis & Kanago, 1998, 2000; Daal, Naka, & Sanchez, 2005; Thornton, 2007; Kiley, 2007). Despite the scarcity of theoretical explanations for this correlation,[1] eventually the relationship has come to be thought of as monotonic. Put simply, high inflation is generally expected to be variable inflation, while conversely low inflation is generally expected to be stable inflation.

Recently, however, Coibion, Gorodnichenko, and Wieland (2012) have presented a theoretical New Keynesian model that not only endogenously generates a relationship between the level and volatility of inflation, but also predicts that this relationship is not monotonic. In particular, their model predicts that the relationship between the level and volatility of inflation is negative at low levels of inflation, becoming positive only when inflation rises above a specific value. Coibion et al. (2012) compute that the break in the relationship occurs at annual inflation of 3.5%. In the rest of the present paper, we refer to this as the CGW Hypothesis.

For an intuition behind the CGW hypothesis, it is helpful to focus on the tension in their New Keynesian model between (a) the probability of hitting the zero lower bound (ZLB) and (b) the firms' optimal pricing decisions. Consider, for example, raising (trend) inflation from a very low value. On the one hand, this lowers the likelihood of hitting the ZLB, thereby *reducing* macroeconomic volatility – including the volatility of inflation. At the same time, the higher inflation causes firms to respond more aggressively in resetting prices, *increasing* inflation volatility. When inflation is below a certain value, estimated around 3.5% by CGW, the ZLB effect is stronger, producing a negative relationship between inflation and its volatility. For values above this threshold, the price-setting effect becomes dominant, generating the more familiar positive relationship between inflation and its volatility.

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[1] Ball (1992) and Kiley (2007) provide two influential exceptions.

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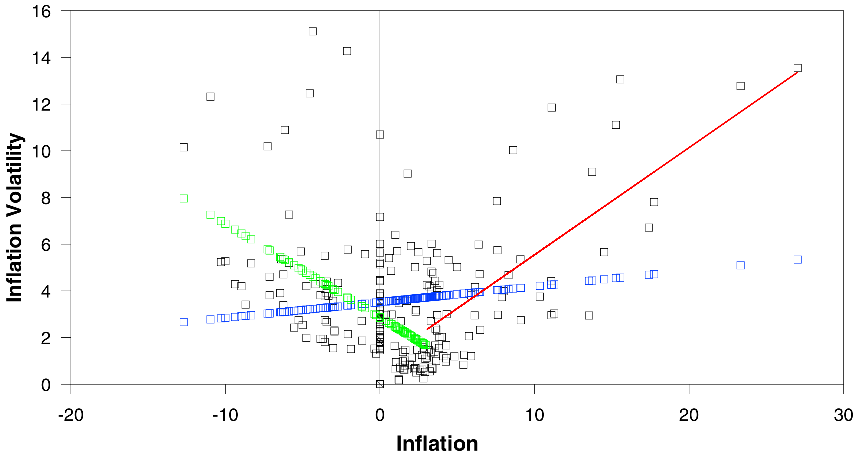

Fig. 1. The relationship between inflation and its volatility is asymmetric.

The significance of such a result for monetary policy is straightforward. Suppose that inflation and its volatility are indeed negatively related when inflation is below a certain threshold. This would then mean that if inflation falls below that threshold, raising it would make inflation more stable – indeed, it would mean that inflation would have to be raised in order to be made more stable.[2]

The goal of this paper is to examine empirically the relationship between inflation and its volatility and test the CGW Hypothesis. Using annual US data over the period 1800–2016, the paper estimates the relationship between several measures of inflation (or trend inflation) and inflation volatility. The main advantage of using such a long data set is that it includes a variety of inflation (and deflation) experiences that are not commonly (or not at all) found in more recent, post-WWII data sets.

Our first finding with this data set is that the overall correlation between inflation and its volatility is positive but not particularly strong. Next, we ask whether the 3.5% inflation value implied by the model of Coibion et al. (2012) really marks a break point in the relationship, and we find that it does: for inflation values higher than 3.5%, the correlation between inflation and its volatility has been positive; while for inflation below 3.5%, the correlation is negative. This is consistent with the CGW Hypothesis.

But is 3.5% the actual break point? To answer that, we use two nonlinear techniques to estimate the break point. One of them, a quadratic model, implies a break point that ranges from 0.8% to 3.2%. Hansen's (1997) technique, however, places the break between 2.3% and 4.3%.[3] Finally, the relationship is also estimated for various subsamples of the full period.

Overall, the paper's findings can be summarized in Fig. 1, a scatterplot of inflation volatility versus inflation in the US over the period 1805–2014 (Section 2 below defines the variables). The blue line shows the overall relationship between the two variables: it is (weakly) positive, and thus consistent with the consensus view. Allowing for a non-monotonic relationship, however, changes the picture drastically. The relationship remains positive (the red line) above a certain value of inflation, but becomes negative (the green line) for inflation below this threshold. The threshold on Fig. 1 is roughly 3% (Section 3 below presents the full range of estimates).

The rest of the paper is organized as follows. Section 2 discusses the data and defines the variables to be used in the estimation. Section 3 outlines the estimation methodology, derives the main empirical results, and implements a number of robustness checks and extensions. Section 4 discusses the findings and concludes.

2. The data

The price level (P_t) is measured by the Consumer Price Index. The source is the Federal Reserve Bank of Minneapolis Consumer Price Index (Estimate), and the data set consists of annual observations covering the period 1800–2016.[4] The inflation rate (π_t) is defined as the percent change in the CPI: $\pi_t = 100 \cdot (P_t - P_{t-1})/P_{t-1}$.

Time-varying *average inflation* ($\bar{\pi}_t$) and our first measure of *inflation volatility* (σ_t^π) series are next constructed using rolling five-year windows: $\bar{\pi}_t$ and σ_t^π are set equal to the mean and standard deviation, respectively, of the inflation rate over each 5-year period.[5]

In addition, we use the Hodrick-Prescott (HP) filter, proposed by Hodrick and Prescott (1997), to decompose inflation into permanent and transitory components. We set the *trend inflation* series ($\bar{\pi}_t^{HP}$) equal to the HP permanent component,[6] and we use again

[2] If the threshold was sufficiently high, this would even strengthen the case of those who call for an increase in the inflation target, such as Blanchard, Dell'Ariccia, and Mauro (2010), and Ball (2013).

[3] It is worth pointing out that similar results have been obtained by Karras (2015a, 2015b, forthcoming) for Japan, United Kingdom, and the United States, for very different time periods.

[4] The full data set is available from the Federal Reserve Bank of Minneapolis website at https://www.minneapolisfed.org/community/teaching-aids/cpi-calculator-information/consumer-price-index-1800.

[5] Longer window lengths (up to 10 years) were also used, but the results are shown to be robust. Middle-of-window values are used for both $\bar{\pi}_t$ and σ_t^π.

[6] In particular, the HP filter defines the trend, $\bar{\pi}_t^{HP}$, as the component that minimizes $\sum_{t=1}^{T}(\pi_t - \bar{\pi}_t^{HP})^2 + \lambda\sum_{t=2}^{T-1}[(\bar{\pi}_{t+1}^{HP} - \bar{\pi}_t^{HP}) - (\bar{\pi}_t^{HP} - \bar{\pi}_{t-1}^{HP})]^2$ for $\lambda > 0$. In the empirical section below we report results for $\lambda = 6.25$, as recommended by Ravn and Uhlig (2002), but we have also tried $\lambda = 100$, the value suggested by Hodrick and Prescott for annual data.