Does High Inflation Lead to Increased Inflation Uncertainty? Evidence from Nine African Countries

Scott W. Hegerty
Northeastern Illinois University

ABSTRACT

The connection between inflation and its volatility—particularly the “Friedman hypothesis,” which stipulates that rapid price rises help fuel inflation uncertainty—has been tested for a number of emerging markets. Yet Africa, which many hope can improve its macroeconomic performance by adopting inflation targeting, has not received as much attention in the empirical literature. This study proxies uncertainty for sub-Saharan Africa with Exponential GARCH models, before testing for relationships using Granger causality tests and impulse-response functions. Inflation increases are shown to fuel uncertainty in all cases, while the reverse relationship holds for only half of the countries. A region-wide extension of the analysis shows that international spillovers are often related to South Africa.

Introduction

In recent decades, many African countries have debated whether the implementation of inflation targeting would help stabilize their economies. While this choice of target is widely used by larger emerging markets, much of the continent chooses to target the monetary base and only a few—notably South Africa in 2000—have made the switch to inflation targeting.

Africa’s often double-digit inflation rates add to the urgency of restructuring monetary policy. A number of studies and working papers have examined the cost and benefits of inflation targeting. Aliyu and Englama (2009), for example, conduct an econometric analysis and recommend that Nigeria adopt an inflation-targeting regime. Sriram (2009) arrives at the same conclusions regarding the Gambia. Heintz and Ndikumana (2010), on the other hand, reject the policy in a study of Sub-Saharan Africa.
As a region.

Besides penalizing investors and posing other problems in Africa, inflation is linked to uncertainty, which imposes clear welfare costs and has the potential to destabilize the entire region. As the continent strives to attract foreign investment, getting both variables under control is paramount. These connections - between inflation and inflation volatility, both within individual African countries and among them - are the focus of this study.

The link from inflation to its uncertainty, known as the “Friedman hypothesis,” is attributed to Friedman (1977) and has been formalized by Ball (1992). The basic premise is that, if inflation is high, policymakers will act to fight it. But, since this might bring about a painful increase in unemployment, these policymakers might hesitate. The resulting action - and the resulting effect on inflation - might be in doubt as a result.

This hypothesis has been tested for a wide variety of countries but, with few exceptions, Africa tends to be omitted. Empirical studies typically employ Vector Autoregression (VAR) methods: If inflation Granger-causes uncertainty, then the Friedman hypothesis is proven. Uncertainty itself is often proxied using Generalized Autoregressive Conditional Heteroskedasticity (GARCH) approaches, which model the time-varying volatility of the error term in a structural or ARIMA model. Introduced by Engle (1982) and extended by Bollerslev (1986), these have proven to be an effective time-series tool.

Recent tests of the “Friedman hypothesis” include one by Fountas et al. (2006), who focus on inflation, as well as output growth, in the G-7. Inflation is shown to Granger-cause uncertainty in all cases, but the reverse relationship is only significant in about half the countries. Payne (2008) examines the Bahamas, Barbados, and Jamaica using monthly data from 1972 to 2007. Also using a GARCH(1,1) variance series as a proxy for uncertainty, he finds that the hypothesis holds for all three Caribbean countries, and that uncertainty influences inflation in Jamaica. Payne (2009) arrives at similar results for Thailand, noting that the effect of uncertainty on inflation is negative, which supports the “stabilization hypothesis” of Holland (1995). Thornton (2007) also employs GARCH methods on a sample of twelve emerging markets over a sample period that
varies from country to country. He includes South Africa (from 1957-2005); inflation is shown to Granger-cause inflation uncertainty, but not vice-versa.

Caporale and Kontonikas (2009), on the other hand, apply regression techniques to assess the effects of inflation on uncertainty in twelve EMU countries over the period from 1973 to 2004. They find that the relationship has a number of breaks, suggesting that the relationship between the two variables is weaker. At the same time, Keskek and Orhan (2010) examine Turkey over the period from 1984 to 2005, employing GARCH-in-Mean (GARCH-M), Component GARCH-M, Threshold GARCH and Exponential GARCH approaches. Their findings support the hypotheses, and like Payne (2008), the authors find that uncertainty has a negative effect on inflation that they also attribute to policymakers’ emphasis on stabilization policy. Finally, Hasanov, and Omay (2011), examining data from 1989 to 2007 for ten Central and Eastern European countries, find that inflation Granger-causes uncertainty in most countries.

Clearly, Africa has been under-analyzed in this body of research. This study aims to fill this gap by estimating these effects for nine sub-Saharan African nations for which data are available, applying EGARCH and EGARCH-M methods to model inflation uncertainty. We then use Granger causality tests, as well as Impulse-Response Functions (IRFs), to examine the relationship between inflation and inflation uncertainty. We find strong support for the Friedman hypothesis for all countries, as well as evidence that uncertainty causes inflation for some of them. Finally, we apply multicountry methods - Granger causality and multivariate GARCH - and find that international spillovers only tend to occur among West African neighbors, or originate in or lead to South Africa. This paper proceeds as follows. Section II outlines the econometric methodology, and Section III provides the results. Section IV concludes.

Methodology

Monthly time series for the Consumer Price Index, beginning in January 1976 and ending in the late 2011 or early 2012, are used in this empirical analysis. These series are not deseasonalized. Inflation is calculated as the month-on-month change of the log CPI series, multiplied by 100. The resulting inflation series, which are shown below to be stationary are then modeled in a standard ARIMA framework, as in Equation (1):
\[ \pi_t = c + \sum_{i=1}^{p} \rho_i \pi_{t-i} + \sum_{j=0}^{q} \theta_j \epsilon_{t-j} \]  

(1)

Eleven monthly seasonal dummies are included, but not reported, throughout this study. The order of \( p \) and \( q \) are chosen via the Box-Jenkins approach. The residuals are then checked for ARCH effects and, showing evidence of time-varying volatility, and then modeled with the EGARCH technique of Nelson (1991). An EGARCH(1,1) variance equation is estimated simultaneously with the mean equation and is depicted as follows:

\[ \ln(h_t) = \alpha_0 + \alpha_1 \left( \frac{\epsilon_{t-1}^{\gamma}}{h_{t-1}^{\gamma}} \right) + \lambda_1 \left( \frac{\epsilon_{t-1}^{\gamma}}{h_{t-1}^{\gamma}} \right) + \beta_1 \ln(h_{t-1}) \]  

(2)

The EGARCH model allows for asymmetries between positive and negative effects. This is important for studies of inflation volatility, because of the particularly destabilizing effect that periods of high inflation can have. We see below that these asymmetries are indeed present in this case. In addition to observing the significance of the coefficients, we also perform a handful of diagnostic tests to determine that we have chosen the correct model.

Because inflation uncertainty might have a positive impact on inflation because risk-averse producers might raise prices more than necessary, or a negative effect per the “stabilization hypothesis,” we also estimate EGARCH-M models for each country. The new mean equation, estimated alongside the original variance equation, is given in (3):

\[ \pi_t = c + \gamma h_t + \sum_{i=1}^{p} \rho_i \pi_{t-i} + \sum_{j=0}^{q} \theta_j \epsilon_{t-j} \]  

(3)

If the volatility term turns out to be significant, we will consider using this alternative in place of a country’s original variance series in our further analysis. Once we have estimated these equations, and have generated either an EGARCH- or EGARCH-M-based volatility series for each country, we proceed in this analysis as follows.

Our main analysis involves conducting bivariate Granger causality tests on each country’s inflation and uncertainty series. We expect inflation to Granger-cause uncertainty; perhaps the effects run the other direction as well. We extend these VAR
approaches to include IRFs, which we generate to evaluate the dynamic effects of shocks to each variable on the other.

Secondarily, we expand our analysis to consider international spillovers: Estimating a VAR containing all countries inflation and volatility series, we perform Granger causality/Block exogeneity tests. Perhaps one country’s uncertainty will lead to inflation elsewhere. We expect there to be limited spillovers occurring anywhere except perhaps for close neighbors, or involving South Africa. Should we find more evidence, then this would suggest that these preliminary results could be expanded into a formal study.

We also test whether volatility can spill over directly from country to country using Multivariate GARCH approaches. These have been applied to the case of interest-rate volatility by Laopodis (2000) and Hegerty (2011). Here, we model each country’s inflation as an AR(1) as in Equation (4), and the cross-country variance series as a “standard” GARCH(1,1) as in Equation (5). We focus here on the constant conditional correlations of Equation (6):

\[
\pi_{i,t} = c + \rho_i \pi_{i,t-1} + \varepsilon_i \quad \text{for all } i
\]

\[
\ln \sigma_{i,t}^2 = \alpha_{i,0} + \sum_j^8 \left( \alpha_{i,j} \phi_{i,j} \varepsilon_{i,t-1}^2 + \beta_{i,j} \ln \sigma_{j,t-1}^2 \right) \quad \text{for all } i, j
\]

\[
\sigma_{i,j,t} = \gamma_{i,j} \sigma_{i,t} \sigma_{j,t} \quad \text{for all } i, j; i \neq j
\]

Using the tests mentioned above, therefore, we are able to answer three key questions. Primarily we are concerned with whether African inflation feeds into inflation uncertainty (and vice versa) for nine individual countries for which data are available. We also test whether these effects occur across countries. Finally, we examine whether inflation uncertainty itself is “contagious.” Our results are presented below.

**Results**

Monthly CPI data were taken from the International Financial Statistics of the International Monetary Fund for this analysis. Inflation series, which all begin in 1976m2, are shown in Figure 1.\(^2\) We see some interesting patterns. Burkina Faso, for example, experienced a clear reduction in inflation in the early 1980s. The same may
Figure 1 - Monthly Inflation Rates for Selected Countries, 1976-2012.
have taken place, but to a lesser degree, in Cote d’Ivoire. The Gambia experienced a period of relatively high volatility in the mid-1980s, while Ethiopia appears to have undergone constant, high inflation throughout the sample period. South Africa and Botswana enjoy the lowest inflation rates.

Some of these patterns are data-related, however, and affect the empirical analysis. Ghana’s series exhibits some seasonal movement that leads us to omit it from further study. South Africa has a number of “zero” values before 1987, possibly because single CPI values are attributed to multiple months. There are two ways to address this latter issue: Do nothing, as was successfully done by Thornton (2007), or begin this country’s sample period in 1987. We choose to do both for comparison purposes, while using the longer series for our multi-country analysis.

Table 1 - Stationarity and ARCH Test Results.

<table>
<thead>
<tr>
<th>Country</th>
<th>Phillips-Perron</th>
<th>Zivot-Andrews</th>
<th>Z-A Break</th>
<th>ARMA(p,q)</th>
<th>ARCH Test</th>
<th>Lag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burkina Faso</td>
<td>-24.812 (0.000)</td>
<td>-12.661</td>
<td>1994m1</td>
<td>2,2</td>
<td>81.221 (0.000)</td>
<td>12</td>
</tr>
<tr>
<td>Botswana</td>
<td>-16.896 (0.000)</td>
<td>-9.689</td>
<td>1996m7</td>
<td>1.2</td>
<td>36.180 (0.000)</td>
<td>12</td>
</tr>
<tr>
<td>Cote d’Ivoire</td>
<td>-18.912 (0.000)</td>
<td>-19.652</td>
<td>1993m12</td>
<td>1.0</td>
<td>47.062 (0.000)</td>
<td>12</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>-16.570 (0.000)</td>
<td>-16.763</td>
<td>2002m5</td>
<td>2.0</td>
<td>25.975 (0.000)</td>
<td>6</td>
</tr>
<tr>
<td>The Gambia</td>
<td>-16.476 (0.000)</td>
<td>-7.203</td>
<td>1990m9</td>
<td>2.1</td>
<td>60.446 (0.000)</td>
<td>11</td>
</tr>
<tr>
<td>Kenya</td>
<td>-16.642 (0.000)</td>
<td>-10.002</td>
<td>1994m5</td>
<td>0.3</td>
<td>10.302 (0.016)</td>
<td>3</td>
</tr>
<tr>
<td>Nigeria</td>
<td>-13.799 (0.000)</td>
<td>-10.196</td>
<td>1996m8</td>
<td>3.0</td>
<td>12.338 (0.055)</td>
<td>6</td>
</tr>
<tr>
<td>Niger</td>
<td>-16.863 (0.000)</td>
<td>-12.935</td>
<td>1993m5</td>
<td>1.1</td>
<td>63.687 (0.000)</td>
<td>4</td>
</tr>
<tr>
<td>South Africa</td>
<td>-19.835 (0.000)</td>
<td>-10.389</td>
<td>1993m5</td>
<td>3.0</td>
<td>33.707 (0.001)</td>
<td>12</td>
</tr>
<tr>
<td>South Africa (1987-)</td>
<td>-12.809 (0.000)</td>
<td>-7.767</td>
<td>2006m1</td>
<td>3.0</td>
<td>4.294 (0.745)</td>
<td>1</td>
</tr>
</tbody>
</table>

The 99% critical value for Zivot-Andrews test is -5.43.

These series are all stationary, and all show evidence of time-varying volatility. Relevant statistics are provided in Table 1. Two stationarity tests, conducted on levels data, concur. These include the Phillips-Perron (1988) test, which is similar to the Augmented Dickey-Fuller test except that it uses Newey-West (1983) heteroskedasticity- and autocorrelation-consistent standard errors), and the Zivot-Andrews (1992) test, which allows for a structural break. Because the series are stationary, we use levels, non-differenced data. Likewise, all series are amenable to ARCH analysis, given the significant ARCH test statistics at optimal lags. The only exception might be the shortened South African sample, but we proceed with it nonetheless.

Next, we form our proxy for inflation uncertainty by estimating EGARCH and EGARCH-M models for each of the nine remaining countries. All except South Africa
are modeled with an order of (1,1). The results are given in Table 2. Overall, the ARCH and GARCH coefficients are significant, and the diagnostics point to having an adequate model.

We see that five series do not have a significant GARCH coefficient (at 10 percent) in Panel B’s mean equation, while five do. Cote d’Ivoire, Niger, and the Gambia are significant at five percent, and the associated p-values are higher for Burkina Faso and Nigeria. While the Akaike Information Criterion suggests that EGARCH-M is a better fit in most cases, the significance levels of the ARCH and GARCH coefficients differ. They are superior, for example, in the EGARCH-M specification in the case of Niger, while they are worse for Cote d’Ivoire. It is therefore ambiguous as to which alternative is preferable, so we create EGARCH variance series for all countries and additional EGARCH-M series for the five countries that warrant it. These series are presented in Figures 2a and 2b. It is difficult to discern visually much difference between the five countries’ alternative series (and as we see below, it is also difficult to do so statistically). Regardless of the measure, we see clear changes in these countries’ inflation volatilities over the sample period. Examples include the above-mentioned reduction in Burkina Faso’s fluctuations and increase in Gambia’s volatility. South Africa has experienced a reduction in uncertainty as well. But Nigeria’s constant high volatility suggests that the country is indeed a prime candidate for an inflation-targeting monetary policy regime.

Does this uncertainty spill over to inflation, and vice-versa? We have already seen that uncertainty raises inflation in five of these nine countries. We test this, alongside the Friedman hypotheses, using VAR analysis. Table 3 provides the results. We place the time series for inflation and our GARCH-based uncertainty proxies into 15 separate VARs (we have ten EGARCH and five EGARCH-M series). Choosing the optimal lag length for each by minimizing the Schwarz Information Criterion (SIC), we test both directions of causality. The first important conclusion is that inflation Granger-causes inflation uncertainty in all cases, confirming the Friedman hypothesis for all nine African countries. Secondly, the other direction of causality—that uncertainty Granger-causes inflation—is confirmed in only half the cases. These are, for the most part, the
same countries that had a significant GARCH-M coefficient. Thirdly, the results are robust across specifications. Using an EGARCH-M variance term in the Granger-causality test does not weaken the impact of volatility on inflation. Shortening South Africa’s sample period also does not change the results of these tests.

Figure 2a - EGARCH Variance Series
EGARCH Series (no GARCH-in-Mean)
Figure 2b - EGARCH-M Series

Table 3 - Granger Causality Test Results.

Panel A: EGARCH Variance Series:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VOL→INF</td>
<td>21.960 (0.000)</td>
<td>0.017 (0.897)</td>
<td>2.441 (0.118)</td>
<td>0.318 (0.573)</td>
<td>12.392 (0.000)</td>
<td>11.296 (0.001)</td>
<td>6.020 (0.049)</td>
<td>1.123 (0.289)</td>
<td>1.606 (0.658)</td>
<td>1.740 (0.419)</td>
</tr>
<tr>
<td>INF→VOL</td>
<td>152.44 (0.000)</td>
<td>57.35 (0.000)</td>
<td>217.73 (0.000)</td>
<td>155.50 (0.000)</td>
<td>155.97 (0.000)</td>
<td>1946.42 (0.000)</td>
<td>474.14 (0.000)</td>
<td>49.98 (0.000)</td>
<td>139.94 (0.000)</td>
<td>56.59 (0.000)</td>
</tr>
</tbody>
</table>

Panel B: EGARCH-M Variance Series:

<table>
<thead>
<tr>
<th>Lags</th>
<th>Burkina Faso</th>
<th>Cote d'Ivoire</th>
<th>The Gambia</th>
<th>Nigeria</th>
<th>Niger</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOL→INF</td>
<td>21.839 (0.000)</td>
<td>2.789 (0.095)</td>
<td>10.676 (0.001)</td>
<td>6.571 (0.037)</td>
<td>0.226 (0.634)</td>
</tr>
<tr>
<td>INF→VOL</td>
<td>87.298 (0.000)</td>
<td>180.77 (0.000)</td>
<td>77.80 (0.000)</td>
<td>435.87 (0.000)</td>
<td>43.72 (0.000)</td>
</tr>
</tbody>
</table>

P-values in parentheses. Bold = significant at 5 percent.
VOL→INF: Ho = Volatility does not Granger cause inflation.
INF→VOL: Ho = Inflation does not Granger cause volatility.
The impulse responses to a one-standard-deviation shock to each variable are provided in Figures 3a and 3b. These confirm the Granger-causality results given above: shocks to inflation lead to increases in volatility in all cases. The responses of inflation to an uncertainty shocks are more ambiguous. The Gambia, as was the case above, responds positively, as does Kenya (which did not occur previously). Cote d’Ivoire and Niger no longer register effects; Nigeria’s are weaker; and Burkina Faso only shows a significantly positive response for the EGARCH-M specification. Nonetheless, the "Friedman hypothesis"—the main focus of this study—holds.

Testing for spillover effects

As a preliminary exercise, we test to see whether inflation and volatility in one country affect the other variable abroad. To do so, we construct an 18-variable VAR, beginning in 1976m2, using only the five EGARCH-M-based volatility series for those countries that had both. The relevant Granger causality/Block exogeneity results are presented in Table 4.
Figure 3b - Impulse-Response Functions Using EGARCH-M Variance Series (With ±2 Standard-Error Bands).
Many of Panel A’s significant coefficients are located on the diagonal, replicating the “own country” Granger causality results above. But there are a few significant cross-country effects, particularly among neighbors in West Africa. Inflation in Cote d’Ivoire has an impact on uncertainty in the Gambia and Burkina Faso; inflation in this latter country affects Cote d’Ivoire as well. The geographic pattern uncovered here is certainly worthy of further study.

Most importantly, Africa’s dominant emerging market and largest inflation-targeter clearly is influential in the region. Inflation in the Gambia and Nigeria both Granger-cause South African inflation uncertainty; inflation in South Africa has the same effect on Burkina Faso, Botswana, Cote d’Ivoire, and Kenya. Most likely, actions by the South African Reserve Bank are closely followed and anticipated within the region.

Panel B of Table 4 shows the effect of uncertainty on inflation internationally. There are fewer significant results, but many of those that remain match the country pairs above. South African volatility Granger-causes inflation in Burkina Faso, while Burkina Faso’s volatility Granger-causes inflation in Cote d’Ivoire. Gambia has the same impact on South Africa. Again, Africa’s most advanced economy is able to affect others across the continent.
The direct relationships among volatility series are much weaker, however. Table 5 provides the Multivariate GARCH conditional correlations. Only one is significant below five percent, although there is a relationship (with a p-value below seven percent) between Burkina Faso and Cote d’Ivoire. South Africa does not seem to experience transmissions of inflation volatility. This suggests that Africa might not have a completely integrated financial market.

Conclusion

The “Friedman hypothesis,” whereby high inflation invites an uncertain policy response and therefore fuels inflation volatility, has been empirically tested for developed and less-developed countries worldwide. Yet, with the exception of its largest economy, few studies have focused on the economies of Africa. This study does so, examining nine countries beginning in 1976.

Modeling uncertainty using Exponential GARCH and GARCH-in-Mean methods, we find that volatility increases inflation in half of the countries. Entering the resulting variance series into bivariate VARs alongside the inflation rate, we conduct Granger causality tests and generate impulse-response functions. Both confirm that inflation increases lead to greater uncertainty in all countries. Finally, multi-country Granger causality tests suggest that regional spillovers are weak except for South Africa and country pairs such as Burkina Faso and Cote d’Ivoire, while Multivariate GARCH estimates fail to uncover much direct transmission of inflation volatility.
These results have clear implications for policy. Most importantly, proponents of inflation targeting might point to the benefit of lower uncertainty, which can lead to reduced social costs and greater inward foreign investment. This is particularly true for those countries where bidirectional causality hints at a “feedback loop” between inflation and uncertainty. Secondarily, South Africa’s importance in the region is highlighted, as most of the international effects are tied to it. There is an intriguing connection between neighbors such as Cote d’Ivoire and Burkina Faso that deserves further study, however. We expect the trends uncovered here to continue: fighting inflation will take on added importance in sub-Saharan Africa, while South Africa’s monetary influence will continue to grow.

References


