JOURNAL OF ECONOMIC DEVELOPMENT
Volume 34, Number 2, December 2009

INFLATION COSTS, UNCERTAINTY COSTS AND EMERGING MARKETS

WILLIAM MILES AND SAMUEL SCHREYER *

Wichita State University and St. Cloud State University

Given the costs to real output that inflation uncertainty has been shown to impose, two recent papers have investigated the interaction of inflation and uncertainty for a group of emerging market nations. Both papers find that an increase in inflation almost invariably increases uncertainty in developing countries. This finding accords with the Friedman hypothesis and with most results for industrialized countries. However, there is both theoretical and some tentative empirical evidence suggesting that, when inflation is high, and thus costly, an increase in inflation can spur greater investment in predicting the path of prices, and actually reduce rather than increase uncertainty. This possibility is particularly relevant for emerging markets, some of which have histories of high inflation. Using a somewhat different empirical methodology than previous authors, we find that inflation does indeed lower uncertainty at some horizons, and, as per theory, does so predominantly in those countries in our sample with the higher rates of inflation.

Keywords: Price Level, Inflation, Deflation, Macroeconomic Analyses of Economic Development
JEL classification: E31, O11

1. INTRODUCTION

Inflation and its related uncertainty can impose costs on real economic output (Friedman (1977), Grier, Olekalns, Shields and Henry (2004), Grier and Grier (2006)). For emerging markets, these costs may be higher than those in industrialized nations. Although hyperinflation is a thing of the past in most developing countries, inflation is still higher than desired in many such nations. In particular, the poor residents of developing countries may be relatively unable to hedge against the costs of rising prices and inflation, when combined with other distortions such as misaligned nominal

* We thank participants at the 2008 Southern Economics Association meetings and Dong Cho for helpful comments. The authors are grateful to an anonymous referee for very helpful comments and suggestions.

exchange rates may cause harmful real exchange rate overvaluation. Some researchers also find that when inflation combines with distortions such as interest rate controls it inhibits financial market development in LDCs (Barnes and Duquette (2006)).

Given the importance of inflation dynamics, a number of papers have investigated the interactions of inflation and uncertainty in the U.S., Europe and Japan (Caporale and McKiernan (1997), Grier and Grier (2006), Grier and Perry (1998), Wilson (2006)). There have only been two multi-country investigations of inflation and uncertainty for emerging markets, however (Daal, Naka, and Sanchez (2005), and Thornton (2007)). Both employ GARCH estimation, which has been demonstrated as superior to the older method of using the unconditional variance of inflation as a proxy for uncertainty. However, there are a number of different GARCH-type models, and each of the two papers imposes one particular kind of GARCH model, without a clear rationale. This makes the results questionable, and indeed, the two authors find opposite results for some countries regarding the effects of uncertainty on inflation.

Imposing an incorrect GARCH model on the inflation process can result in incorrect inference. Accordingly, in this study we investigate a number of GARCH models for developing countries, and after allowing for flexible selection of the ARMA process, choose the GARCH model that exhibits the greatest likelihood (as will be discussed, standard model selection criteria such as SIC, adjusted R^2, etc. are inapplicable to GARCH models). We then investigate inflation for ten developing countries, and find results that contradict both of the previous authors. These results are important given the relatively high inflation rates in many of the countries in the study and they are suggestive that the cost of inflation is indeed higher in these LDCs than previous studies have indicated.

This paper proceeds as follows. The next section details the previous literature on the theory and empirics of inflation and uncertainty. The third section describes our data and methodology. The fourth section discusses the results, and the fifth section concludes.

2. PREVIOUS LITERATURE

The seminal paper on the impact of inflation on uncertainty was by Friedman (1977). He argued that when inflation rises, agents are uncertain as to whether policymakers will endeavor to lower price increases, and thus uncertainty over the future price path rises. Ball (1992) formalizes Friedman’s argument in a theoretical model. Thus the Friedman-Ball hypothesis states that there is a positive impact of inflation on inflation uncertainty.

At the same time, there can also be an impact of inflation uncertainty on inflation itself. Cukierman (1992) employs a Barro-Gordon framework to show that an increase in uncertainty raises the optimal inflation rate. Thus Cukierman posits a positive impact of uncertainty on inflation.

Inflation uncertainty is important, indeed potentially more important for output than the level of inflation itself. While a low or moderate level of inflation may be neutral for long run output, uncertainty can have a negative effect on income. Friedman points to the deleterious effect inflation uncertainty has on the information content of prices and hence on exchange, and Cabellero (1991) points out that higher uncertainty can lower investment and hence output.

This negative impact of uncertainty on output is more than a theoretical possibility. Grier, Henry, Olekalns and Shields (2004) find a negative impact of inflation uncertainty on growth in the United States, while Grier and Grier (2006) find a negative impact of uncertainty on income growth in Mexico.

Given that inflation uncertainty negatively impacts output, Holland (1995) advances the opposite hypothesis of Cukierman-namely, that an increase in inflation uncertainty should lower inflation. Holland argues that policy makers are aware of the high costs of uncertainty, and thus when uncertainty rises, some central banks may make strong efforts to lower inflation, and thus uncertainty. The effect of uncertainty on inflation is therefore theoretically ambiguous.

Accordingly, some previous empirical studies find mixed results regarding the effect of uncertainty on inflation, with a positive impact for some countries, and a negative effect for others (see Grier and Perry (1998), Daal, Naka and Sanchez (2005) and Thornton (2007)). On the other hand, most studies find that there is an almost uniformly positive effect of inflation on uncertainty.

However, Pouregami and Maskus (1987) argue that if the cost of inflation is sufficiently high, agents will invest more resources into correctly forecasting price changes in response to an increase in inflation. This may be the case for many developing countries, in which a high level of inflation can extract high economic costs. Pouregami and Maskus (1990) find, in a sample of seven Latin American countries, that higher inflation raises the size of inflation forecast errors in Brazil and Peru, but lowers these errors in Argentina, a notoriously high inflation country where failure to correctly anticipate price changes can wreak large economic costs.

Ungar and Zilberfarb (1993) develop a formal model in which the effect of inflation on uncertainty depends on the costs of inflation versus the cost of gathering information to forecast inflation. Thus unlike in the Friedman-Ball scenario, an increase in inflation may decrease uncertainty if inflation is sufficiently costly relative to the costs of obtaining information to generate more accurate predictions.

The potentially negative effect of inflation on uncertainty, due to the cost of inflation being sufficiently high to offset costs of information-gathering and forecasting, may be particularly relevant for emerging market countries, as opposed to industrialized nations. Bruno and Easterly (1998), and Khan and Senhadji (2000) document that high levels of inflation exert a negative effect on growth while low levels of inflation do not. Emerging market countries have higher levels of inflation and thus are more likely to suffer from the costs of inflation.

Thus, just as the effect of uncertainty on inflation is theoretically ambiguous, so too is the effect of inflation on uncertainty. While studies for industrialized countries generally find a positive effect of inflation on uncertainty (Grier and Perry (1998) find the impact is uniformly positive in the G-7), the impact in developing nations may not be so uniform.

In order to investigate the impact of inflation and uncertainty on each other, some empirical proxy for uncertainty must be obtained. A traditional measure of inflation uncertainty has been the variance of inflation, but Grier and Grier (2006) note that inflation can be both highly variable and predictable. A subsequent measure of uncertainty was the variance of different forecasters' predictions of inflation (Holland, 1993).

Grier and Grier (2006), however, point out that the variance of inflation forecasts may be a flawed measure of uncertainty. The authors note that each forecaster may have a large confidence interval around their point forecast, but that the collective forecasts may show little variability.

Most modern investigations of inflation uncertainty thus employ GARCH models. Inflation is first modeled as an ARMA process:

$$y_t = \sum_{i=1}^{p} a_i y_{t-i} + \sum_{i=0}^{q} b_i \varepsilon_{t-i} , \tag{1}$$

where y_t is the current inflation rate. If we assume that agents have rational expectations, then the residuals ε_t represent forecast errors. We further posit in an ARCH model that the variance is time-varying, as follows:

$$\varepsilon_t = v_t h_t^{0.5} . \tag{2}$$

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 . \tag{3}$$

Here, h_t is the conditional variance, and v_t is white noise, so that the residual ε_t still has an expected value of zero. We interpret the time-varying ARCH variance as inflation uncertainty. This has become standard practice in modern studies on inflation uncertainty (Grier and Grier (2006), Grier and Perry (1998), Daal, Naka and Sanchez (2005), Thornton (2007)). For modeling convenience, rather than the AR process indicated in Equation (3), the conditional variance is sometimes specified as an ARMA (or GARCH) process:

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} . \tag{4}$$

While there have been a number of papers on inflation and uncertainty in industrialized countries, only two multi-country studies have been carried out for the developing world. Daal, Naka and Sanchez (2005, DNS hereafter) investigate inflation and uncertainty for fifteen emerging markets, as well as the G-7 economies, while Thornton (2007) examines these interactions for twelve developing countries. DNS find that, in all developing countries, the effect of inflation on uncertainty is positive, and significant in all cases but one (Peru). Thornton's results similarly indicate a positive effect, although in two cases (Colombia and Israel) the effect is negative at twelve lags, but positive at eight and four lags.

Thus existing results would seem to indicate that the Pouregami and Maskus (1987, 1990) and Ungar and Zilbefarb (1993) hypothesis of a potential negative effect of inflation on uncertainty is essentially irrelevant, even in developing countries where the cost of inflation is potentially quite high. Indeed, none of the three papers just mentioned is cited in either DNS or Thornton.

However, the results of DNS and Thornton may be due to misspecification. Each imposes a particular ARMA and GARCH model on all of the countries under investigation, despite the fact that there are many potential ARMA and GARCH models which may be optimal in each nation. Indeed, upon reflection, it is extremely unlikely that inflation and uncertainty dynamics are the same in each nation. There is one GARCH model imposed on all countries in each paper, but the models are different between the two papers, and the two studies reach different conclusions for certain countries on the effect of uncertainty on inflation.

Given that the two papers impose different models uniformly on all countries with little statistical rationale, and have conflicting results for particular countries on how inflation and uncertainty interact, we will we will employ a more flexible approach. We will allow each country to have its own ARMA-GARCH model, as again it is highly unlikely that inflation dynamics are identical for each. Moreover, our results will differ from both DNS and Thornton for a number of countries. In particular, we find that in those countries with the highest inflation in our sample, inflation negatively impacts uncertainty, bolstering the hypothesis of Pouregami and Maskus.

3. DATA AND METHODOLOGY

We obtain data on consumer prices from the International Financial Statistics (IFS) database. We have data on the following countries: Argentina, Colombia, Mexico, Peru and Venezuela, from 1957:1 through 2006:11, India from 1957:4 through 2006:10, Indonesia from 1968:2 through 2006:11, Korea from 1970:2 through 2006:11, Thailand from 1965:2 through 2006:11, and Turkey from 1970:1 through 2006:10. It should be noted that both DNS and Thornton also have differing sample periods for the countries in their studies.

We next turn to specifying the ARMA-GARCH model for each country. Again, it is extremely unlikely that each country exhibits the same inflation dynamics, and thus it is appropriate that each country be allowed its own possible model. In contrast, DNS begin their modeling procedure by imposing on each nation an ARMA (p, 1, 12) specification. That is, the number of AR parameters is allowed to vary by country, but all nations have first and twelfth MA terms. Thornton does allow for a varying number of AR terms in different countries, but does not allow for any MA parameters.

In this paper, we fit ARMA models by first examining which ARMA model leads to the lowest AIC and SIC for each country. We then determine whether one or both of the models chosen by these criterion display uncorrelated residuals. If so, that will be the model chosen. If the best model by these selection criteria still display autocorrelation, we experiment with various AR and MA lags until the residuals appear to be white noise, and this will be the ARMA portion of the GARCH model. The only exception will be Venezuela, for which no model can be found which "whitens" the residuals, and thus the model chosen by the SIC will be employed.

The next step is to specify a GARCH model. DNS impose a Power-GARCH (PARCH) model on all the countries in their paper. Thornton employs a standard GARCH(1,1) model. Again, these impositions assume that the conditional volatility of inflation follows an identical model specification across all countries.

There are many different types of GARCH models, and imposing just one type on all countries can lead to serious misspecification. Different GARCH models have been developed to capture different types of behavior on the part of the changing volatility in economic and financial variables. While we cannot examine every possible GARCH specification, we will choose from three, which address issues of asymmetry in inflation shocks, avoidance of non-negativity constraints and capturing long-term persistence in inflation volatility.

A standard GARCH(1,1) model, as in Equation (4), has been most commonly applied (Bollerslev (1986)). This model often captures most of the conditional volatility in a series, in that a series that is fitted with a GARCH(1,1) specification often has no remaining ARCH effects in its residuals. Caporale and McKiernan (1997) and Grier and Perry (1998) apply the GARCH(1,1) model in studying inflation and uncertainty in the U.S. and all G-7 countries, respectively. Thornton (2007) applies this model to twelve emerging market nations.

There are some shortcomings of the standard GARCH model, however, and several researchers have developed different specifications designed to overcome these problems. First, as the variance can never be negative, the model requires non-negativity constraints on the parameters in Equation (4). All of the α's and β's being non-negative is a sufficient condition for non-negativity. Unfortunately, the estimated coefficients may actually be negative (Nelson (1991)) and restricting the sample parameters in this way "may unduly restrict the dynamics of the conditional variance process" (Nelson, p. 347), and thus lead to poor specification.

Another and potentially more serious drawback of the standard GARCH model is that it imposes symmetric effects of positive and negative inflation shocks. That is, a negative shock to inflation has the same impact on uncertainty as a positive shock.

Brunner and Hess (1993) argue that this would be contrary to the Friedman hypothesis. Indeed, it is easy to imagine that agents become more certain over the future path of inflation if the central bank successfully disinflates.

Finally, a potentially important issue for inflation dynamics is the often persistent nature of the conditional variance. Several GARCH models have been proposed to capture a level of persistence in volatility that the standard GARCH model fails to incorporate. Engle and Lee (1999), for instance, developed the Component-GARCH (C-GARCH) model to capture the "long memory" property of stock returns.

Again, there are many GARCH models designed to address these issues in economic data. While we cannot fit each inflation series to every possible GARCH model, we will fit each country's inflation to four GARCH models which have become quite prominent and which address such issues. First, we will examine the GARCH(1,1) model. As noted, this has been a workhorse in the literature, and is the specification Thornton (2007) chose for his study of emerging markets.

The second model is known as exponential-GARCH, or E-GARCH (Nelson, 1991). It is specified as:

$$\ln(h_t) = a_0 + a_1(\varepsilon_{t-1} / h_{t-1}^{0.5}) + \gamma\left|\varepsilon_{t-1} / h_{t-1}^{0.5}\right| + \beta \ln(h_{t-1}) . \tag{5}$$

Since the model is in log form, the value of h_t can never be negative, and thus this specification allows for negative parameter values. Perhaps more importantly, an E-GARCH process can exhibit asymmetric behavior; if $\varepsilon_{t-1} / h_{t-1}^{0.5}$ is positive, the effect of a shock on the conditional variance is $a_1 + \gamma$. If however, there is a negative shock, the effect on the conditional variance is $\gamma - a_1$. Since it is quite possible that positive shocks to inflation raise uncertainty more than negative innovations, this model may be more appropriate than the standard GARCH. Wilson (2006) employs this specification in modeling inflation and uncertainty in Japan.

Additionally, the Power-ARCH (PARCH) model, developed by Ding, Engle and Granger (1993) is also capable of capturing asymmetric effects of positive and negative shocks. Ding, *et al.* specify their model as:

$$(h_t^{0.5})^{\delta} = a_0 + \sum_{i=1}^{p} a_1(\left|\varepsilon_{t-1}\right| - \varphi\varepsilon_{t-1})^{\delta} + \sum_{i=1}^{q} \beta_i (h_{t-i}^{0.5})^{\delta} . \tag{6}$$

Since DNS employed this model in their study, we will do so as well. We also set the parameter δ equal to 2 as is done in the DNS study.

Finally, the conditional volatility of inflation may be highly persistent and standard GARCH models may under-estimate this persistence. There are a number of models designed to deal with this persistence. The aforementioned Component GARCH (C-GARCH) model of Engle and Lee captures long memory in volatility by replacing the conditional variance in (4) with two different components:

$$h_t = \rho_t + a_1(\varepsilon_{t-1}^2 - \rho_{t-1}) + \beta_1(h_{t-1} - \rho_{t-1}) \tag{7}$$

$$\rho_t = \alpha_1 + \alpha_2\rho_{t-1} + \alpha_3(h_{t-1} - \rho_{t-1})\,. \tag{8}$$

Unlike a typical GARCH model (4), in which the conditional variance reverts to a long run mean, a_0 in the case of (4), in the component GARCH specification the level to which h_t reverts, ρ_t, is time varying. Thus Equation (7) represents the transitory component of the conditional variance, while (8) captures the long memory portion of volatility. Grier and Perry (1998) applied this model to inflation and uncertainty in G-7 nations, so we will see if it applies to inflation and uncertainty in emerging market nations.

After fitting the ARMA portion of our inflation models, we will estimate all four types of GARCH models, and choose the one with the highest likelihood. This is not a formal test, but it gives some indication of the best model, and is better than imposing one model on all of the countries. The reason for choosing the model with the greatest likelihood is that, while criteria such as AIC and SIC are useful for models of the conditional mean, Bollerslev, Engle and Nelson (1994) point out that their statistical properties are unknown for GARCH models (see also Enders (2004, pp. 135-136) for a discussion).

Then, once the ARMA-GARCH model has been selected, we will follow DNS and Thornton and perform Granger-causality tests between inflation and the estimated conditional variances. This will allow for the testing of hypotheses at the four, eight and twelve month lag levels, as in Thornton.

4. RESULTS

Table 1 lists the ARMA models for the ten countries under study. In five of the ten cases (Argentina, Korea, Peru, Thailand and Turkey), the model chosen by the SIC criterion leads to no remaining autocorrelation, and is thus employed. In one other case, Venezuela, the SIC-chosen model is used, despite the existence of autocorrelation in the residuals, since, despite repeated experimenting, autocorrelation remains. In the remaining four countries, neither the models chosen by the AIC or SIC criteria led to uncorrelated residuals, so experimentation led to the models that were eventually chosen, which are free of autocorrelation.

Table 1. ARMA Models

Country	ARMA Model	Serial Correlation LM Test P-Value
Argentina	ARMA(5,2)*	0.479
Colombia	AR(8)	0.725
India	AR(5)	0.103
Indonesia	AR(6)	0.566
Korea	ARMA(2,1)*	0.349
Mexico	AR(9)	0.173
Peru	AR(2)*	0.255
Turkey	ARMA(1,2)*	0.795
Thailand	ARMA(6,9)*	0.424
Venezuela	ARMA(2,12)*	0.036

Note: An asterisk indicates a model chosen by the SIC criterion.

We then proceeded to estimate GARCH, E-GARCH, PARCH and C-GARCH models. For Indonesia, none of the models led to convergence in the parameter estimates, so we proceed with the other nine nations. As displayed in Table 2, for three nations, (Colombia, India and Venezuela) PARCH is the best model, in two (Argentina, Peru) E-GARCH is chosen, in two others (Korea and Thailand) standard GARCH achieves the highest likelihood, and finally in two countries (Mexico and Turkey) C-GARCH is the best specification. We then obtain estimates of inflation uncertainty with the conditional variance, and perform Granger-causality tests of the impact of inflation and uncertainty on each other. Results are displayed in Table 3.

Table 2. GARCH Models

Country	Coefficient	P-Value	Country	Coefficient	P-Value
Argentina			Peru		
E-GARCH			E-GARCH		
a_0	-0.056	0.000	a_0	-0.515	0.000
a_1	0.87	0.000	a_1	0.944	0.000
γ	0.202	0.002	γ	0.37	0.005
β	0.97	0.000	β	0.96	0.000
Colombia			Thailand		
PARCH			GARCH		
a_0	0.00009	0.5312	a_0	1.81	0.06
a_1	0.069	0.0004	a_1	0.09	0.013
φ	-0.39	0.035	β	0.878	0.000
β	0.917	0.000			

India			Turkey		
PARCH			C-GARCH		
a_0	0.024	0.112	a_1	0.392	0.294
a_1	0.031	0.9	β_1	0.583	0.14
φ	-0.95	0.901	α_1	3385	0.591
β	0.905	0.000	α_2	0.99	0.000
			α_3	0.0766	0.858
Korea			Venezuela		
GARCH			PARCH		
a_0	5.49	0.1843	a_0	0.045	0.008
a_1	0.195	0.002	a_1	0.292	0.0025
β	0.758	0.000	φ	-0.508	0.01
			β	0.686	0.000
Mexico					
C-GARCH					
a_1	0.484	0.000			
β_1	0.512	0.000			
α_1	991.6	0.000			
α_2	1.00	0.000			
α_3	-0.113	0.009			

As in DNS, we will perform Granger Causality tests to determine whether, at each given lag length, inflation affects uncertainty, and vice-versa, and then use the sign of the sum of the coefficients on the individual lags to determine whether the effect is positive or negative. In some cases, of course, the signs on the coefficients will conflict-some being positive, and others negative. In a few cases, where the sum is negligibly positive or negative, we will report this as a wash. We believe this is more accurate than falsely claiming a very significant effect based on an infinitesimally small positive or negative sum.

For Argentina, at twelve lags, inflation and uncertainty both Granger-cause each other, but in both cases there are conflicting signs on the estimated parameters and the net effect is roughly a wash. At four and eight lags, inflation has a net negative effect on uncertainty. This accords with the idea that, given Argentina's inflation history, it is extremely costly for agents to underestimate the impact of a rise in prices. Accordingly, a rise in the price level leads to increased resources being devoted to forecasting and other hedging activities, and actually lowers uncertainty, contrary to the Friedman-Ball hypothesis. For Colombia, an increase in inflation lowers uncertainty at all lags. Indeed, of the nine countries in which we obtain convergent GARCH models, four display a negative impact of inflation on uncertainty over some horizon, and three of the five nations in which there is a uniformly positive impact of prices on uncertainty (Korea, India and Thailand) are the nations with the lowest average inflation rates in our sample (see Table 3). These findings bolster Pouregami and Maskus' (1987, 1990) results indicating that in high inflation countries, an increase in inflation may actually result in better forecasts of the future price path.

Table 3. Granger Causality Results

	Friedman-Ball	Cukierman
Argentina		
Four Lags	620***(−)	43.11***(−)
Eight Lags	560***(−)	80.59***(−)
Twelve Lags	500.1***(ns)	83.74***(ns)
Colombia		
Four Lags	63.3***(−)	1.36
Eight Lags	29.8***(−)	2.51**(+)
Twelve Lags	21.5***(−)	7.84***(−)
India		
Four Lags	117***(+)	2.92**(−)
Eight Lags	65.7***(+)	2.44**(ns)
Twelve Lags	44.3***(+)	2.36***(ns)
Korea		
Four Lags	43.5***(+)	4.81***(+)
Eight Lags	23***(+)	1.69*(+)
Twelve Lags	15.1***(+)	1.02
Mexico		
Four Lags	24.95***(+)	2.98**(ns)
Eight Lags	18.1***(+)	3.043***(−)
Twelve Lags	10.85***(+)	8.36***(+)
Peru		
Four Lags	1252***(−)	9.3***(−)
Eight Lags	643***(+)	6.1***(−)
Twelve Lags	468***(−)	33.3***(−)
Turkey		
Four Lags	361***(+)	8.75***(−)
Eight Lags	239***(+)	5.43***(+)
Twelve Lags	164***(+)	4.6***(−)
Thailand		
Four Lags	50.5***(+)	4.5***(+)
Eight Lags	29.8***(+)	2.3**(+)
Twelve Lags	20.9***(+)	3.8***(+)
Venezuela		

Four Lags	68***(−)	2.3*(−)
Eight Lags	35.7***(+)	2.6***(−)
Twelve Lags	32.8***(+)	22.8***(−)

Notes: The Friedman-Ball results are the test statistics for the hypothesis that inflation has no effect on uncertainty. The Cukierman results are the test statistics for the hypothesis that uncertainty has no effect on inflation. * denotes significance at the ten percent level, ** denotes significance at the five percent level, and *** denotes significance at the one percent level. The term (ns) denotes no clear positive or negative sign.

It is also important to note that this negative estimated impact of inflation on uncertainty in the high inflation countries in our sample contradicts the existing empirical results of DNS (2005) and Thornton (2007). DNS find, after having imposed an ARMA(p, 1,12)-PARCH(1,1) model on all nations, that inflation always significantly raises uncertainty for all nine of the emerging markets in our sample, as well as all other emerging markets that these authors investigate (the one exception is Peru, where the effect is positive, but not significant). Thornton (2007), after imposing an AR-GARCH(1,1) model on all countries, finds that there is a negative effect of inflation on uncertainty only in Colombia, and only at twelve lags. For four and eight lags, Thornton finds that inflation has a positive impact on uncertainty, unlike in our model (Thornton also found a negative effect of inflation on uncertainty for Israel at twelve lags, but we did not include it in our sample as its status as an emerging market is very questionable). Thus, by allowing for different dynamics in inflation and uncertainty across countries, we have found results that confirm the theory and empirical findings of Ungar and Zilberfarb and Pouregami and Maskus, that higher inflation induces greater efforts to forecast prices changes.

In investigating the Cukierman-Meltzer hypothesis, we find that uncertainty typically lowers inflation in Argentina. This finding accords with that of DNS. In Colombia, India, Korea and Mexico, the impact of uncertainty on inflation is mixed, varying by the number of lags. In Peru, the effect is clearly negative, which contradicts the DNS results (Thornton did not include Peru in his study). For Turkey, the impact is mixed, while both DNS and Thornton find a negative impact. In Thailand, the effect is always positive, while in Venezuela it is unambiguously negative, and the latter finding accords with DNS.

5. CONCLUSION

At first glance, finding that inflation actually lowers uncertainty in high inflation countries may suggest that price stability is less of a concern in emerging markets. Since much of the real cost of inflation arises from uncertainty, if agents are able to better forecast price changes in the face of greater inflation, the negative impact of inflation may not be as pronounced as feared.

However, these results, and recent inflation developments in emerging markets offer no reason for complacency. That agents in high inflation LDCs devote resources to generating accurate predictions suggests that inflation, especially when inaccurately forecast, indeed extracts substantial costs. Moreover, the resources devoted to reducing uncertainty clearly have alternative uses, especially in developing countries still struggling to escape poverty and increase growth.

Finally, it is noteworthy that after making much progress in the last two decades in lowering inflation, prices are rising again in many emerging markets in the wake of the commodity boom and lax monetary conditions. While the prior disinflation of past years may have shifted the Phillips curve relationship inward, it also may have pivoted the curve, giving it a flatter slope. This has been the experience in other countries (Ball Mankiw and Romer (1988), Walsh (1995). See Walsh, 1995 for a discussion of the theoretical reasons why a successful disinflation makes subsequent disinflations more costly in terms of lost output). Thus if higher inflation does again take hold, it could be more costly than in earlier years in terms of lost output to get prices back under control.

Thus, while for some high inflation developing countries, an increase in inflation may not increase damaging uncertainty, this is merely symptomatic of the high costs of inflation in these emerging markets. For this, and the above-cited reasons, failure to maintain vigilance against rising prices will impose real economic costs in emerging markets.

REFERENCES

Ball, L. (1992), "Why Does High Inflation Raise Inflation Uncertainty?" *Journal of Monetary Economics*, 83, 185-191.

Ball, L., N. Mankiw, and D. Romer (1988), "The New Keynesian Economics and the Output-Inflation Tradeoff," *Brookings Papers on Economic Activity*, 1, 1-65.

Barnes, M., and N. Duquette (2006), "Threshold Relationships among Inflation, Financial Market Development and Growth," *Journal of Financial Transformation*, 17, 141-149.

Bollerslev, T. (1986), "Generalized Autoregressive Conditional Heteroscedasticity," *Journal of Econometrics*, 31, 307-327.

Bollerslev, T., R. Engle, and D. Nelson (1994), "ARCH Models," in Engle, R., and D. McFadden, eds., *Handbook of Econometrics*, 4, Elsevier.

Bruno, M., and W. Easterly (1998), "Inflation Crises and Long-Run Growth," *Journal of Monetary Economics*, 41, 3-26.

Cabellero, R. (1991), "On the Sign of the Investment-Uncertainty Relationship," *American Economic Review*, 81, 279-288.

Caporale, A., and B. McKiernan (1997), "High and Variable Inflation: Further Evidence on the Friedman Hypothesis," *Economics Letters*, 54, 65-68.

Cukierman, A. (1992), *Central Bank Strategy: Credibility and Independence*, MIT Press.

Cukierman, A., and A. Meltzer (1986), "A Theory of Ambiguity, Credibility and Inflation under Discretion and Asymmetric information," *Econometrica*, 54, 1099-1128.

Daal, E., A. Naka, and B. Sanchez (2005), "Re-examining Inflation and Inflation Uncertainty in Developed and Emerging Economies," *Economics Letters*, 89, 180-186.

Ding, Z., C. Granger, and R. Engle (1993), "A Long Memory Property of Stock Market Returns and a New Model," *Journal of Empirical Finance*, 1, 83-106.

Enders, W. (2004), *Applied Econometric Time Series*, John Wiley and Sons.

Engle, R., and G. Lee (1999), "A Long-Run and Short-Run Component Model of Stock Market Volatility," in Engle, R., and H. White, eds., *Cointegration, Causality and Forecasting*, Oxford University Press.

Friedman, M. (1977), "Nobel Lecture: Inflation and Unemployment," *Journal of Political Economy*, 85, 451-472.

Grier, R., and K. Grier (2006), "On the Real Effects of Inflation and Inflation Uncertainty in Mexico," *Journal of Development Economics*, 80, 478-500.

Grier, K., O. Henry, N. Olekalns, and K. Shields (2004), "The Asymmetric Effects of Uncertainty on Inflation and Output Growth," *Journal of Applied Econometrics*, 19, 551-565.

Grier, K., and M. Perry (1998), "On Inflation and Inflation Uncertainty in the G-7 Countries," *Journal of International Money and Finance*, 17, 671-689.

Holland, S. (1993), "Comment on Inflation Regimes and the Sources of Inflation Uncertainty," *Journal of Money, Credit and Banking*, 25, 515-520.

_____ (1995), "Inflation and Uncertainty: Tests for Temporal Ordering," *Journal of Money, Credit and Banking*, 27, 827-837.

Khan, M., and A. Senhadji (2000), "Threshold Effects in the Relationship between Inflation and Growth," IMF Working Paper, 00/110.

Nelson, D. (1991), "Conditional Heteroscedasticity in Asset Returns: A New Approach," *Econometrica*, 59, 347-370.

Pouregami, A., and K. Maskus (1987), "The Effects of Inflation on the Predictability of Price Changes in Latin America: Some Estimates and Policy Implications," *World Development*, 15, 287-290.

_____ (1990), "Inflation and Its Predictability in High-Inflation Latin American Countries: Some Evidence on Two Competing Hypotheses-A Research Note," *Journal of International Development*, 2, 373-379.

Thornton, J. (2007), "The Relationship between Inflation and Inflation Uncertainty in Emerging Market Economies," *Southern Economic Journal*, 73, 858-870.

Ungar, M., and B. Zilberfarb (1993), "Inflation and Its Unpredictability-Theory and Empirical Evidence," *Journal of Money, Credit and Banking*, 25, 709-720.

Walsh, C. (1995), "Central Bank Independence and the Short-Run Output-Inflation Tradeoff in the EC," in Eichengreen, B., Frieden, J., and von Hagen, J., eds., *Monetary and Fiscal Policy in an Integrated Europe*, Springer-Verlag.

Wilson, B. (2006), "The Links between Inflation, Inflation Uncertainty and Output Growth: New Time Series Evidence from Japan," *Journal of Macroeconomics*, 28, 609-620.

Mailing Address: William Miles; Department of Economics, Wichita State University, 1845 Fairmount, Wichita, KS 67260-0078, U.S.A. Tel: 316-978-7085. Fax: 316-978-3308. E-mail: william.miles@wichita.edu.

Received December 26, 2008, Revised September 14, 2009, Accepted October 13, 2009.