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INFLATION UNCERTAINTY IN CHILE: ASYMMETRIES AND THE NEWS IMPACT CURVE*

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Abstract

This article presents a historical analysis of inflation in Chile from 1933 to 2001, using generalized autoregressive heteroskedasticity models and including extensions such as the Threshold, Quadratic and Box-Cox models. Traditional symmetric models do not reject Friedman's (1977) hypothesis that inflation increases with uncertainty. We show, however, that a class of more general, asymmetric models rejects this hypothesis (this result does not hold for the asymmetric Box-Cox model). Furthermore, we found that high levels of uncertainty in inflation increase the level of inflation with some lags and do not reject the positive correlation suggested by Cukierman and Metzler (1986). The News Impact Curve reflects those asymmetries.

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I. Introduction

Evidence from many studies leads to the conclusion that high levels of inflation damage economic growth, in fact, that inflation is bad for any economy[1]. Based on this argument, in the past 30 years policy makers concerned about inflation and hyperinflationary processes have adopted alternative stabilization programs, mostly based on non flexible exchange rate regimes. In this environment which focused on the level of inflation, relatively little attention was paid to inflation uncertainty.

Friedman (1977) raised the issued whether high levels of inflation increase inflation uncertainty. In his Nobel Lecture where he proposed the “natural-rate hypothesis”, he also made another statement: the higher the rate of inflation, the more volatile it is likely to be. Using a basic empirical analysis and applying some basic theory, he proceeded to justify his proposal.

There exists empirical research over a wide range of economies that has tested Friedman’s hypothesis. Standard linear econometric models have been employed to test it with remarkable success. These experiences have provided policymakers with strong fundamentals to justify their economic stabilization programs, although the problem of choosing the appropriate mix of monetary and fiscal policy to achieve this ambitious objective remains. Another possibility is to experience multiple state of nature each represented with different stochastic models, especially regarding the sequence of stabilization processes adopted by the chilean authorities during the middle 70s and during the 90s.[2]

However, although many empirical studies back up Friedman’s hypothesis, theoretical support for those findings remains lacking. To fill this gap, Ball (1992) uses the Barro-Gordon repeated game structure to build a model of monetary policy in which a rise in inflation leads to more uncertainty about future inflation. Based on imperfect public information about the actual and future preferences of policymakers, and given low levels of inflation, there is no risk of opportunistic behavior from the authorities, so inflation uncertainty will be low. If inflation is high, however, the public is unable to identify the current authorities’ preferences, thus increasing the likelihood that the policy-maker would postpone a stabilization program, in order to avoid the recession that would probably result.

At the same time as Ball, Cukierman (1992) raised an alternative hypothesis. He suggested that an opportunistic central bank could consider high uncertainty as an opportunity to raise inflation levels using expansionary monetary policies. This hypothesis was rejected, however, for Mexico and G7 countries (Grier and Grier, 1998; Grier and Perry, 1998).

This paper explores these hypotheses, considering a range of asymmetric volatility models, extending the approach followed by Magendzo (1998). Asymmetric models confirm Magendzo’s findings and there is evidence of Cukierman’s opportunistic monetary policies in the sample. The News Impact Curve (NIC) shows the asymmetric characteristics present in most financial time series, confirming the hypothesis that positive inflationary shocks have more impact on volatility than similar negative shocks.

The paper is organized as follows. Section II presents alternative inflation volatility hypotheses, while Section III introduces alternative volatility model specifications. The next section presents estimation results applied to Chilean monthly inflation data, and explores asymmetric behavior using the News Impact Curves developed by Pagan and Schwert (1990) and Engle and Ng (1993). Finally, the paper closes with our conclusions.

II. Hypothesis on Inflation Volatility

After Friedman (1977) postulated that high levels of inflation should cause an increase in inflation uncertainty, many empirical studies have tested this hypothesis. Strong support is found in the data, especially for the US and other economies (Caporale and McKiernan, 1997; Evans, 1991; Grier and Grier, 1998; Grier and Perry, 1998; Nas and Perry, 2000; and Wang *et al*., 1999).

Given the lack of a specific model to support Friedman's hypothesis, Ball (1992) presents a theoretical model using elements from Barro and Gordon (1983). The model assumes that when actual and expected inflation are low, economic agents will expect that monetary authorities to implement policies to keep inflation low. However, when inflation is high, given the fear of recession that would result if they implement restrictive monetary policies, economic agents are unsure about future inflation. Given this fear, authorities may decide to postpone stabilization programs, or perhaps to implement them as soon as possible. This makes agents uncertain.

With the reverse causality, Cukierman and Metzler (1986) and Cukierman (1992) argue that sometimes policymakers take advantage of high volatility to raise inflation. However, this hypothesis has not found empirical support (Grier and Perry, 1998). This is the second theory tested in this paper.

The usual approach has been to estimate general autoregressive conditional heteroskedasticity models, considering symmetric and occasionally mean reverting extensions. Asymmetric models such as Box-Cox models were not considered, with the consequential misspecification problem. The next section explores symmetric and asymmetric behavior of inflation volatility using alternative specification models and monthly data from 1933 to 2001.

III. Alternative Model Specifications

This section presents alternative heteroskedastic model specifications to study inflation volatility in Chile on a monthly basis from 1933:02 to 2001:06.

The classical or benchmark model used as a starting point is the Generalized Autoregressive Conditional Heteroskedasticity model (GARCH), developed by Bollerslev (1987), which can be represented by the following system for inflation and inflation volatility:

$$\pi_t = \mu + \sum_{j \in J} \rho_j \pi_{t-j} + \varepsilon_t \tag{1}$$
$$\varepsilon_t \sim N(0, \sigma_t^2)$$
$$\sigma_t^2 = \beta_0 + \sum_{i=1}^{i=q} \gamma_i \varepsilon_{t-1}^2 + \sum_{i=1}^{i=p} \beta_i \sigma_{t-i}^2$$

where J, p, q are identified using standard time series procedures. This representation does not include any variables (inflation in variance or variance in inflation model) representing the alternative hypothesis mentioned previous section.

Considering the hypothesis that the level of inflation could influence inflation volatility, as Friedman (1977) and Ball (1992) initially remarked, the GARCH equation should include inflation lags as additional explanatory variables. Moreover, to consider the hypothesis that inflation volatility could affect the level of inflation, it is necessary to incorporate lags of inflation volatility as explanatory variables for inflation in the first equation of the system (GARCH-M representation). Both hypotheses can be represented using the following system of equations:

$$\pi_t = \mu + \sum_{j \in J} \rho_j \pi_{t-j} + \sum_{\kappa \in \mathrm{K}} \theta_\kappa \sigma_{t-\kappa} + \varepsilon_t \tag{2}$$
$$\varepsilon_t \sim N\left(0, \sigma_t^2\right)$$
$$\sigma_t^2 = \beta_0 + \sum_{i=1}^{i=q} \gamma_i \varepsilon_{t-i}^2 + \sum_{i=1}^{i=p} \beta_i \sigma_{t-i}^2 + \sum_{s \in S} \psi_S \pi_{t-s}$$

where J, K and S should be empirically defined using standard statistical procedures (Akaike and Schwarz criterion).

Based on Friedman and Ball's hypothesis, the ψ_s parameter must be statistically significant with a positive sign, while Cukierman's θ_k parameter should be significant and positive too.

Grier and Grier (2000) estimate the previous model to analyze inflationary processes in Mexico. Their estimation validated the Friedman and Ball hypothesis, in the sense that high levels of inflation increase uncertainty, but rejected Cukierman's hypothesis. In fact, they found that high volatility is associated with lower, not higher inflation. Grier and Perry (1998) found similar results for the United States and Germany.

However, studies have focused primarily on symmetric models, where inflationary shocks (positive or negative) have the same impact on volatility. Several asymmetric models evaluate alternative behavior. Among them *Quadratic GARCH* (QGARCH), *Threshold*-GARCH (TGARCH), *Glosten-Jagannathan-Runkle* GARCH (GJR-GARCH) model, and finally the non linear asymmetric *Box-Cox GARCH* model (Box-Cox-AGARCH), which encompasses most of the linear asymmetric models just mentioned.

The QGARCH(1,1) model using inflation and volatility as explanatory variables can be represented by [3]:

$$\pi_t = \mu + \sum_{j \in J} \rho_j \pi_{t-j} + \sum_{\kappa \in \mathrm{K}} \theta_\kappa \sigma_{t-\kappa} + \varepsilon_t \tag{3}$$

$$\varepsilon_t \tilde{} N\left(0,\ \sigma_{\mathrm{t}}^2\right)$$

$$\sigma_t^2 = \beta_0 + \gamma_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \varphi \varepsilon_{t-1} + \sum_{s \in S} \psi_s \pi_{t-s}$$

where φ is the asymmetric parameter which helps to separately identify the impact on volatility of positive and negative inflationary shocks. A positive size 1 shock will have an impact on volatility equivalent to $\gamma_1 + \varphi$, while a similar sized negative shock will have an impact of $\gamma_1 - \varphi$, instead of $-(\gamma_1 + \varphi)$ as the symmetric model predicted.

The volatility equation for the TGARCH(1,1) model is represented by:

$$\sigma_t^2 = \beta_0 + \gamma_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \varphi \tau_{t-1} \varepsilon_{t-1}^2 + \sum_{s \in S} \psi_s \pi_{t-s} \tag{4}$$

where the τ parameter works as a threshold indicator function, following the process represented by:

$$\tau_{t-1} = \left\{ \begin{matrix} 1 \text{ if } \varepsilon_{t-1} \le 0 \\ 0 \text{ if } \varepsilon_{t-1} > 0 \end{matrix} \right\} \tag{5}$$

If a negative inflationary shock occurs, the impact on volatility will equal $\gamma_1 + \varphi$, while if the shock is positive, the impact will be just γ_1, because for this event $\tau = 0$.

The model introduced by Glosten, Jagannathan and Runkle (1993) satisfies the asymmetric requirement with an alternative approach. The volatility equation is reformulated to:

$$\sigma_t^2 = \beta_0 + (1 - \alpha_{t-1}) \gamma_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \varphi \alpha_{t-1} \varepsilon_{t-1}^2 + \sum_{s \in S} \psi_s \pi_{t-s} \tag{6}$$

where the indicator function is defined by:

$$\alpha_{t-1} = \left\{ \begin{matrix} 0 \text{ if } \varepsilon_{\mathrm{t-1}} \le 0 \\ 1 \text{ if } \varepsilon_{t-1} > 0 \end{matrix} \right\} \tag{7}$$

This means that a positive inflationary shock will affect volatility by φ, while a negative shock impact will be γ_1, with no restriction on the estimated parameters φ and γ_1. In this representation, the GJR-GARCH model gives similar results to the TGARCH model.

An additional model is that presented by Hentschel (1995), which nests the most important GARCH models, except the Quadratic GARCH model. Depending on the parameter values adopted by the vector $[\lambda, \nu, \delta_0, \delta_1]$, this general representation is able to simulate actual volatility processes such as GARCH, TGARCH, or exponential GARCH (see Table 1).

TABLE 1

NON LINEAR ASYMMETRIC VOLATILITY MODEL

Volatility Model	Parameter			
	λ	ν	δ_0	δ_1
GARCH	2	2	0	0
TGARCH	1	1	0	Free
GJR-GARCH	2	2	0	Free

This asymmetric general expression called Box-Cox-AGARCH(1,1) could be represented by:

$$\frac{\sigma_t^{\lambda}-1}{\lambda} = \beta_0 + \gamma_1 \sigma_{t-1}^{\lambda} f^{\nu}\left(\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right) + \beta_1 \frac{\sigma_{t-1}^{\lambda}-1}{\lambda} + \sum_{s \in S} \psi_s \pi_{t-s} \tag{8}$$

$$f\left(\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right) = \left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \delta_0\right| - \delta_1\left(\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \delta_0\right)$$

where its asymmetric behavior comes from the existence of function $f\left(\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right)$, which has two parameters, δ_0 and δ_1, representing the non-symmetric evolution of inflation volatility when a positive or a negative shock affects inflation.

IV. Model Estimations and the News Impact Curve

This section presents an application of several univariate GARCH-like specifications for inflation (π). We consider monthly *Consumer Price Index* data from January 1934 through June 2001. Inflation is defined as the monthly difference in the natural logarithm of the Consumer Price Index $(\pi_t = 100 \cdot \ln\left(\frac{CPI_t}{CPI_{t-1}}\right))$. The natural logarithm of the CPI was previously seasonally adjusted using X-12.[4, 5]

The time series model for inflation was defined by choosing among the minimum Akaike and Schwarz statistics, exploring a grid from one to fifteen lags in the AR(p) process. The final estimated model was an AR(1) represented by (standard errors in parenthesis):

$$\pi_t = \underset{(0.119979)}{0.8253} + \underset{(0.026534)}{0.6513}\, \pi_{t-1} + \varepsilon_t \tag{9}$$

The squared residuals behavior shows an ARCH process (ARCH-Test: $TR^2 = 91.08$, while White test returns 116.8, both with zero p-values). In addition, it was tested for stationarity using the augmented Dickey-Fuller (ADF) and Phillips-Perron unit root test with a constant and six lags for the first difference of inflation. We reject the null hypothesis of the unit root in the inflation process at the 0.01 level, indicating that inflation is stationary (i.e., I (0)) in our sample. This stationarity result is natural to be expected, and reverse some of the findings reported in García and Restrepo (2001). These results validate efforts to estimate a conditional heteroskedasticity model for inflation.

4.1 Inflation extended GARCH

The GARCH-M system and results are represented in the following table and equation. The estimated system considers the lag as affecting volatility over inflation once one lag is included in the mean equation as an explanatory variable. Previous models consider one lag only, excluding effects from previous months. This persistence effect is captured in our estimations.

$$\pi_t = \mu + \rho\pi_{t-1} + \theta_1\sigma_{t-1} + \theta_2\sigma_{t-2} + \theta_3\sigma_{t-3} + \varepsilon_t \tag{10}$$

$$\sigma_t^2 = \beta_0 + \gamma_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \psi\pi_{t-1}$$

The GARCH model, extended to include volatility lags and inflation, helps to explain the actual volatility of inflation. Contrasting these two models using a likelihood ratio test rejects the null hypothesis that the restricted and unrestricted equations are equal, so the extension is valid.

Friedman and Ball's hypothesis, represented by parameter ψ, is rejected, meaning that high inflation will not increase uncertainty (volatility). However, the Cukierman hypothesis, represented by the vector of parameters $[\theta_1\ \theta_2\ \theta_3]$, is not rejected in the sense that an increase in inflation uncertainty will cause higher inflation, revealing unstable inflationary policies adopted by the Central Bank during the sampling period.

TABLE 2

SYMMETRIC GARCH MODEL

Parameter	GARCH(1,1)	GARCH(1,1)-M(3)
μ	0.4749 (0.2137)	0.1667 (0.0737)
ρ	0.5008 (0.1356)	0.3125 (0.1058)
β_0	0.0252 (0.0322)	– 0.0234 (0.0111)
γ_1	0.1716 (0.0423)	0.1709 (0.0510)
β_1	0.8266 (0.0434)	0.8158 (0.0517)
ψ		0.0373 (0.1444)
θ_1		– 0.051 (0.2819)
θ_2		0.5818 (0.2337)
θ_3		0.0767 (0.0381)
LogL	– 1556.27	– 1495.63
LR – Test *(P – Value)*	121.28 (0.000)	

Note: Standard Errors in parenthesis.

4.2 Inflation extended QGARCH

The QGARCH-M estimations are presented in the following table:

$$\pi_t = \mu + \rho\pi_{t-1} + \theta_1\sigma_{t-1} + \theta_2\sigma_{t-2} + \theta_3\sigma_{t-3} + \varepsilon_t \tag{11}$$

$$\sigma_t^2 = \beta_0 + \gamma_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \psi\pi_{t-1} + \varphi\varepsilon_{t-1}$$

TABLE 3

QUADRATIC GARCH MODEL

Parameter	QGARCH(1,1)	QGARCH(1,1)-M(3)
μ	0.4018 (0.1703)	0.1673 (0.0718)
ρ	0.5358 (0.1357)	0.3133 (0.1062)
β_0	0.0305 (0.0192)	– 0.022 (0.0237)
γ_1	0.1747 (0.0384)	0.1691 (0.0652)
β_1	0.8231 (0.0390)	0.8179 (0.0691)
ψ		0.0739 (0.0656)
φ	0.1229 (0.0613)	0.0036 (0.0503)
θ_1		0.0409 (0.1745)
θ_2		– 0.054 (0.3189)
θ_3		0.5811 (0.2530)
LogL	– 1544.63	– 1495.65
LR – Test *(P – Value)*	97.96 (0.000)	

Note: Standard Errors in parenthesis.

The inflation-adjusted QGARCH model helps to explain the actual volatility of inflation without rejecting some degree of asymmetry present in the data. An evaluation of these two restricted and unrestricted models using a likelihood ratio test rejected the null hypothesis that equations are equivalent. The estimated ψ was 0.0739 with a t-test of 1.12, not rejecting the null hypothesis (that the coefficient is zero), meaning a rejection of Friedman's hypothesis, so high or low levels of inflation do not affect inflation uncertainty.

However, the Cukierman and Metzler's hypothesis is not rejected if more than one or two volatility lag are included as explanatory variables in the GARCH-M equation. The positive and significative value of θ_3 denotes some kind of persistence of volatility over inflation, a characteristic not present in earlier studies. Hence, an increase in inflation uncertainty does imply higher inflation, typically with a three-month lag.

4.3 Inflation extended TGARCH

The TGARCH-M estimation model, denoted by:

$$\pi_t = \mu + \rho\pi_{t-1} + \theta_1\sigma_{t-1} + \theta_2\sigma_{t-2+} + \theta_3\sigma_{t-3} + \varepsilon_t \tag{12}$$

$$\sigma_t^2 = \beta_0 + \gamma_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \psi\pi_{t-1} + \varphi\tau_{t-1}\varepsilon_{t-1}^2$$

is presented in the following Table 4.

TABLE 4

THRESHOLD GARCH MODEL

Parameter	TGARCH(1,1)	TGARCH(1,1)-M(3)
μ	0.3327 (0.1080)	0.1447 (0.0558)
ρ	0.5790 (0.0959)	0.3100 (0.0955)
β_0	0.0110 (0.0080)	– 0.0127 (0.0080)
γ_1	0.2435 (0.0530)	0.1957 (0.0526)
β_1	0.8398 (0.0314)	0.8459 (0.0413)
ψ		0.0448 (0.0292)
φ	– 0.1683 (0.0692)	– 0.100 (0.0679)
θ_1		0.1109 (0.1825)
θ_2		– 0.0208 (0.2541)
θ_3		0.5203 (0.2459)
LogL	– 1540.56	– 1489.70
LR – Test *(P – Value)*	101.71 (0.000)	

Note: Standard Errors in parenthesis.

The inflation-adjusted Threshold GARCH model helps to explain the actual volatility of inflation when some degree of asymmetry is present in the data. A comparison of the models using a likelihood ratio test, rejects the null hypothesis (that restricted and unrestricted equations are equivalent). Individual t-test reports some information about the Friedman and Cukierman hypothesis that is worth exploring.

Friedman and Ball's hypothesis ($\psi > 0$) is not rejected in the TGARCH model. The parameter estimate is 0.0448 and presents a t-test of 1.53, which yields a probability value in the neighborhood of 6%. This means that different levels of inflation do influence inflation uncertainty, with 10% statistical significance. The Cukierman and Metzler theory, represented by the value for each element of the vector of parameters $[\theta_1\ \theta_2\ \theta_3]$, is not rejected. Hence, as with the previous GARCH and QGARCH models, an increase in inflation uncertainty certainly does loring higher levels of inflation, even when the impact occurs three months later, as with the QGARCH.

4.4 Inflation extended GJR-GARCH

The GJR-GARCH-M estimation model, denoted by:

$$\pi_t = \mu + \rho\pi_{t-1} + \theta_1\sigma_{t-1} + \theta_2\sigma_{t-2} + \theta_3\sigma_{t-3} + \varepsilon_t \tag{13}$$

$$\sigma_t^2 = \beta_0 + \gamma_1(1-\tau_{t-1})\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \psi\pi_{t-1} + \varphi\tau_{t-1}\varepsilon_{t-1}^2$$

is presented in Table 5.

The inflation-adjusted GJR-GARCH model helps to explain the volatility of inflation when some degree of asymmetry is present in the data. A comparison of these models using a likelihood ratio test, rejects the null hypothesis (that restricted and unrestricted equations are equivalent).

Friedman's hypothesis is not rejected in the GJR-GARCH model, given that the test $\psi = 0$ is rejected by the historical data. The actual estimate of 0.0707 with 0.0228 standard error, reports a t-test of 3.106, which yields a probability value in the neighborhood of 0%. That is, different levels of inflation do influence inflation uncertainty.

Furthermore, Cukierman and Metzler's theory, represented by the positive value for the sum of the parameters of the vector $[\theta_1\ \theta_2\ \theta_3]$, is not rejected. Hence, as in the previous GARCH, QGARCH and TGARCH models, an increase in inflation uncertainty does bring with it higher levels of inflation, but again, as in previous models, with some lags.

TABLE 5

GJR-GARCH MODEL

Parameter	GJR-GARCH(1,1)	GJR-GARCH(1,1)-M(3)
μ	0.3327 (0.1080)	0.1002 (0.0594)
ρ	0.5790 (0.0958)	0.3059 (0.0974)
β_0	0.0110 (0.0079)	– 0.0216 (0.0057)
γ_1	0.0752 (0.0399)	0.1093 (0.0477)
β_1	0.8398 (0.0305)	0.8298 (0.0366)
ψ		0.0707 (0.0228)
φ	0.2435 (0.0518)	0.2074 (0.0493)
θ_1		0.4501 (0.2256)
θ_2		– 0.2278 (0.3557)
θ_3		0.4309 (0.2857)
LogL	– 1540.56	– 1492.11
LR – Test *(P – Value)*	96.90 (0.000)	

Note: Standard Errors in parenthesis.

4.5 The asymmetric Box-Cox-GARCH model

This is the most general asymmetric model to estimate volatility. The optimization routine includes a very complex convergence process.[6] This is why we estimate the simplest version of the model (still highly non-linear and with nine parameters), represented by the following system[7]:

$$\begin{aligned} \pi_t &= \mu + \rho \pi_{t-1} + \theta_1 \sigma_{t-1} + \theta_2 \sigma_{t-2} + \varepsilon_t \\ \frac{\sigma_t^{\lambda} - 1}{\lambda} &= \beta_0 + \gamma_1 \sigma_{t-1}^{\lambda} f^{\nu}\left(\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right) + \beta_1 \frac{\sigma_{t-1}^{\lambda} - 1}{\lambda} + \psi \pi_{t-1} \\ f\left(\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right) &= \left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \delta_0\right| - \delta_1\left(\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \delta_0\right) \end{aligned} \tag{14}$$

As mentioned, the Box-Cox asymmetric model is highly non-linear, time and computer intensive. Among the algorithms available in the GAUSS library, the Newton-Raphson algorithm combined with the Brent line search method gave us very stable results.

TABLE 6

BOX-COX-ASYMMETRIC GARCH MODEL

Parameter	AGARCH(1,1)	AGARCH(1,1)-M(3)
μ	0.3564 (0.1190)	0.1492 (0.0220)
ρ	0.6019 (0.0772)	0.3825 (0.0226)
β_0	– 0.2181 (0.1079)	– 0.2980 (0.0283)
γ_1	0.3466 (0.1762)	0.3505 (0.0331)
β_1	0.6787 (0.3879)	0.6596 (0.0617)
ψ		0.0479 (0.0098)
θ_1		0.3040 (0.1368)
θ_2		0.3161 (0.1269)
λ	1.3414 (2.0340)	1.1926 (0.1595)
ν	0.9822 (0.5972)	0.6100 (0.0864)
δ_0	– 0.1247 (0.0731)	– 0.2120 (0.0362)
δ_1	0.0158 (0.2117)	0.0678 (0.0767)
LogL	– 1518.53	– 1451.88
LR – Test *(P – Value)*	133.31 (0.000)	

Note: Standard Errors in parenthesis.

As in previous versions, the extended model was not rejected. Friedman's hypothesis (that price stabilization monetary policies positively reduce volatility) was validated. In fact the parameter ψ equals 0.0479, with standard error of 0.0098, implying a t-test around 4.9 and strongly rejecting the null hypothesis (of the zero coefficient).

Parameters λ and ν are very close to one, reflecting the fact that the model that actually represents volatility is very close to the TGARCH (see Table 1). An in-deep description of these results follows.

4.6 News Impact Curves (NIC)

Engle and Ng (1993), and Pagan and Schwert (1990) proposed the analysis of volatility models based on News Impact Curves (NIC). This curve shows the response in inflation volatility to positive and negative idiosyncratic shocks.[8]

GARCH models have a symmetrical shape, regardless of the sign of the shock. However, asymmetric linear and non-linear models display shapes biased according to the variable being analyzed. For instance, typically in financial time series, volatility NIC functions are biased toward the negative side of the figure, that is, negative shocks loring more volatility than positive shocks of the same magnitude. The market gets nervous when asset prices fall unexpectedly.

In the case of inflation, the analysis is the inverse. An unexpected rise in inflation boosts volatility by more than a similar but negative surprise. This is reflected in Figure 1 where, except for the GARCH model, which is symmetric by definition, the asymmetric associated parameter actually skews the shape towards a north-western orientation.

FIGURE 1

NIC FOR STANDARD MODELS

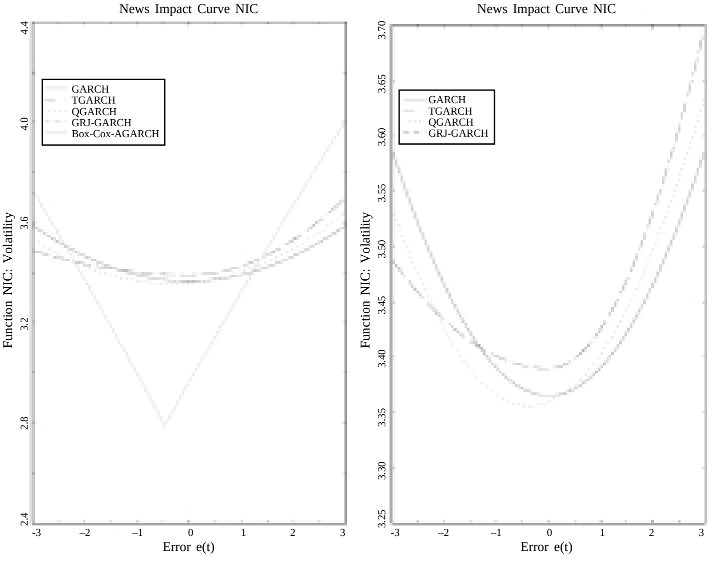


FIGURE 2

NIC FOR EXTENDED (INFLATION AND VOLATILITY) MODELS

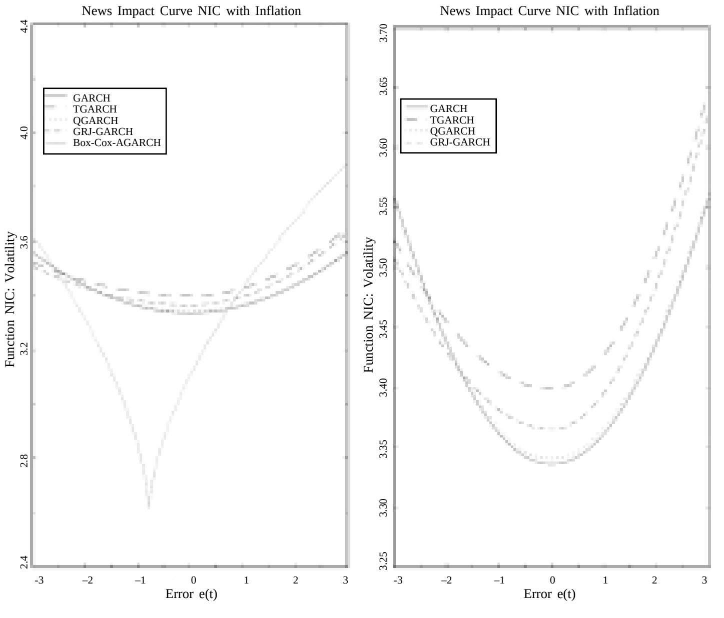
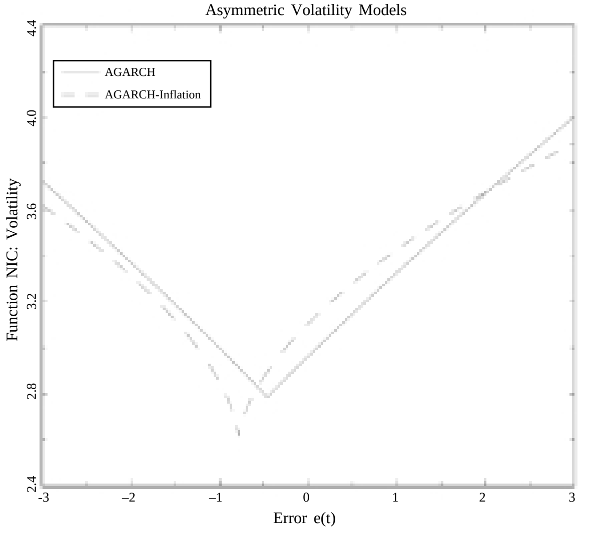


FIGURE 3

NEWS IMPACT CURVES FOR NON LINEAR ASYMMETRIC MODELS



This characteristic is even clearer in the non-linear asymmetric Box-Cox model. Considering that most of the associated parameters are significatives, the V-shape reflects the negative impact on volatility coming, for instance, from negative oil price shocks. This shape is even more pronounce when the extended model is estimated. Figure 2 shows the quasi-V-shape implied in the NIC function.

Once we compare the asymmetric non-linear model for the basic, and inflation-volatility extended versions, the importance of Friedman and Cukierman's hypothesis becomes evident. As we mention in previous sections, these parameters are significant for this asymmetric and non-linear representation, increasing the power of both hypotheses. The persistence effect of volatility on inflation, discussed but never proved in previous studies, demonstrates the importance of reducing volatility by implementing stabilization programs, which lower inflation (Friedman's and Cukierman's together). The empirical "loop" says that it is necessary to reduce inflation to decrease volatility, that these new low levels of volatility will help diminish inflation further, and the iterative convergence will continue. This is a great result for monetary authorities, which can now see the benefits of inflation stabilization programs and new inflation targeting regimes, such as Chile's since the 90s more clearly.

V. Conclusion

This paper analyzes inflation in Chile from 1934 to 2001, and presents evidence in favor of the Friedman hypothesis, which established that high levels of inflation increase inflation uncertainty. To do this, we employ a large set of symmetric, asymmetric and non-linear models, to achieve the necessary results. These demonstrate that negative inflationary surprises, such as oil price shocks, increase inflation volatility more than one would expect from a similar sized but positive shock.

Furthermore, the often mentioned persistence effect is econometrically tested with positive results. In fact, it is common to all models that one-lag volatility has almost a null impact or explanatory power for current inflation. However, two or even three period-lags are very important in explaining inflationary processes (Cukierman's hypothesis).

The opportunistic behavior found in the paper reinforce the idea of implementing stabilization policies or inflation targeting schemes such as the one adopted in Chile in the early 90s, settling the structure for breaking this discretional behavior, reducing uncertainty and inflation.

Notes

1 For a discussion of these issues see Andres and Hernando (1997), Fisher (1996), Sarel (1996), and Dornbusch (2000).

2 I thank the referee for suggesting this alternative approach and that certainly will be included in future research (Engle and Kroner, 1995).

[3] To simplify, we report the family with order p = 1 and q = 1, with inflation and volatility as explanatory variables.

[4] Available at http://www.census.gov/srd/www/x12a/x12down_pc.html.

[5] An alternative approach is suggested by Harvey (2001) which is able to capture seasonal components not observed with the X-12 procedure. In this paper the serie considered in the procedure was the CPI en logs, which gives similar results to the one obtained with Harvey's method. I thank one referee for this clarification.

[6] GAUSS code is available upon request.

[7] This representation includes only two lags of σ^2 in the mean equation because the algorithm was extremately unestable for convergence with the specification used in previous models. It was used the *Constrained Maximum Likelihood* module available in GAUSS for estimations.

[8] Hentschel (1995), and Johnson (2001) present applications of this methodology to financial markets.

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