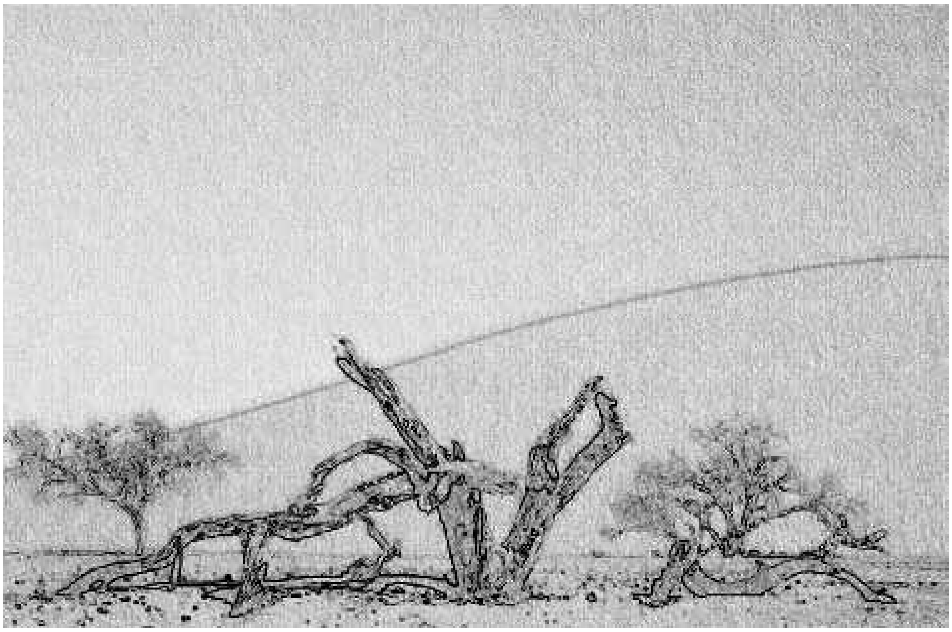

Empirical analysis on the real effects of inflation and exchange rate uncertainty: The case of Colombia

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• ***Resumen.*** Este trabajo reexamina los efectos de la inflación y sus cambios inesperados en la actividad económica. La literatura ha acentuado la diferencia entre incertidumbre respecto a la inflación y la incertidumbre del cambio en desarrollo económico o en diversas medidas de actividad económica. Este artículo procura ocuparse de los dos aspectos analizando las magnitudes y la dirección del efecto de ambos. Para ello se simulan cambio en la política monetaria, usando un modelo condicional auto regresivo (GARCH) que simula los cambios de la inflación. Los resultados sugieren que niveles más altos de la inflación causan más incertidumbre y viceversa para la economía colombiana.

• ***Abstract.*** This paper re-examines the effects of inflation and exchange rate uncertainty on real economic activity. The existent literature has treated both issues as separate subject matters. It has emphasized either the issue of inflation uncertainty or exchange rate uncertainty on economic growth or on different measures of economic activity. This paper attempts dealing with both issues by analyzing the magnitudes and direction of the effect of both: inflation and exchange rate uncertainty on real economic activity. By introducing dummy variables, we control for monetary policy change (the change to inflation targeting and flexible exchange rate). By using a generalized autoregressive conditional variance (GARCH) model of inflation and exchange rates, the conditional variances of the model's forecast errors were extracted as measures of uncertainty. The results suggest that higher levels of inflation Granger cause more uncertainty and vice versa for the Colombian economy. Also, only inflation uncertainty matters for output by exerting a negative influence.

Key Words: Inflation Targeting, Inflation Uncertainty, Exchange Rate, Uncertainty, GARCH models, Granger causality.

JEL Classification: E52, E65, F41, D81

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1. Introduction

Ever since Milton Friedman's nobel lecture (Friedman, 1977) "most of economic theorists have tended to think that what mainly affects economic activity is not necessarily the level of inflation but the incapacity of the economic agents to predict it".[1] Empirical economists have tried to investigate the potential of increased inflation to create nominal uncertainty under the assumption that it will lower welfare and output growth. The claim is that there is a positive correlation between inflation and nominal uncertainty, which runs from inflation to uncertainty about future inflation.

Due to the social costs that high inflation levels and an uncertain environment can bring to the economy, most countries have engaged in a fight against inflation. In particular, many Latin American countries have moved towards the independence of their Central Banks and the adoption of inflation targeting. This situation has allowed some of these countries to achieve sustainable levels of inflation that are converging to steady state

1 Magendzo, I., 1997. "Inflación e incertidumbre inflacionaria en Chile". Documentos de Trabajo del Banco Central, No.15.

values and to the standards of industrialized nations. Colombia's Central Bank became independent in the 1990's, with the 1991 National Constitution, and during the last few years, it has followed a policy of flexible exchange rates, inflation targeting and monetary policy rules; what Taylor (2000) has called "the divine trinity." Since then, there has been an outstanding reduction of the inflation rate and in the level of indexation.

This research is a new attempt in directing this area of research. It seeks to find a way to integrate the problem of inflation uncertainty and exchange rate uncertainty in the context of inflation targeting and flexible exchange rates. A priori expectations would indicate that, due to inflation targeting, inflation uncertainty is lower. Nonetheless, the so called "trinity rule" that requires for small open economies to move towards a flexible exchange rate system, raises the question of how to deal with exchange rate volatility.

The motivation of the paper comes from the fact that the role of exchange rate in an inflation targeting system is still not well defined. Much research is still needed since it is known that exchange rate variations are more costly in small highly open economies with foreign currency denominated debt. Specifically, I investigate the effects of inflation and inflation uncertainty on output in Colombia and the effects of exchange rate uncertainty on Colombian exports for the period 1980:1-2003:12. First, I attempt to review the relationship between inflation, inflation uncertainty and its effects on output. In this sense, two dummy variables are introduced in the conditional variance of inflation accounting for the period of inflation targeting and the period when exchange rates were let to float. Since the second issue comes from the instability generated in the foreign market, the same analysis is done for exchange rates. The idea is to analyze if, after inflation targeting, there was a reduction of inflation uncertainty at the expense of an increase in exchange rate volatility.

2. Literature Review

The existing literature on inflation and exchange rate uncertainty has treated both issues as separate subject. It has emphasized either the issue of inflation uncertainty or exchange rate uncertainty on economic growth or on different measures of economic activity.

Most of the literature on exchange rates and exchange rate uncertainty has been specialized in the area of international finance or international trade. It has focused mainly on the effects of uncertainty on export activity and capital inflows (such as foreign direct investment). Different techniques have been used to model uncertainty. However GARCH models have been the most popular technique in the last few years. In most studies, exchange rate uncertainty has had a negative impact on export activity and foreign direct investment, because as stated by Dixit and Pyndick (1994), uncertainty increases the value option of waiting and therefore it decreases the flows of capital to a country.

For inflation, the literature is broader and contains more theoretical arguments than the research on exchange rate uncertainty. The usual theoretical argument has been that inflation has a negative effect on economic efficiency and growth because higher levels of inflation lead to: (i) greater uncertainty about the future inflation and (ii) greater dispersion of relative prices. Thus, there have been various studies trying to prove what has been called the "Friedman Hypothesis". These studies are of two kinds: those that have tried to prove that higher inflation levels and inflationary uncertainty are correlated and those that have tried to test the impact of inflation and inflation uncertainty on economic growth.

The sources of inflation uncertainty can be decomposed into two broad categories[2]: "Regime Uncertainty" and "Certainty Equivalence". In the first category, future inflation may be uncertain because agents are unsure about the characteristics of the current policy regime (also about a future one, if the current is going to change). Even if the current policy regime were known in each period (certainty equivalence), there would still be uncertainty about the structure of the inflation process within each regime. For a given country, inflation uncertainty will change over time as agents use new information to update their perceptions of structural parameters and the current policy regime. This suggests that the levels of uncertainty during a transition period to price stability will differ from uncertainty that would prevail once the price stability regime is fully recognized by agents.

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2 This is according to Evans and Watchel (1993) as cited in Crawford & Kasumovich (1996).

Empirical studies have measured inflation uncertainty using proxies obtained from surveys of forecasters or econometric models of inflation. According to Grier & Grier (1998), most tests do not control for the real effects on inflation uncertainty, and those that do, use a measure that captures variability but not uncertainty. Grier & Perry (1999) argue that volatility and uncertainty is not necessarily the same thing. If volatility is predictable by rational agents, then there can be a very large amount of inflation volatility and very little actual uncertainty. For Della Mea and Pena (1994), variability is more like an *ex-post* concept; it is referred to the value that inflation takes period by period and its fluctuations towards a mean value. Even if the variability is big, inflation can still be predictable, if agents are rational, there can be a coexistence of high variability and low uncertainty about inflation. If uncertainty is an *ex-ante* concept, it is also subjective; it depends intrinsically on the characteristics of the process that generates expectations.

With the development of econometrics, as the literature turned to time series tests, the two uncertainty measures typically used are either the cross-sectional dispersion of individual forecasts from surveys or a moving standard deviation of the variable under consideration. Recently, academic papers have moved towards the employment of GARCH models. In contrast to the above measures, it has been argued by many authors[3] that GARCH specifically estimates a model of the variance of unpredictable innovations in inflation, rather than simply calculating a variability measure from the past outcomes (moving standard deviation) or conflicting individual forecasts. That is, a GARCH model estimate a time varying residual variance that corresponds well to the notion of uncertainty. Table 1 presents a compilation of the empirical literature on inflation uncertainty.

[3] See Grier & Perry (1999), Ma(1998).

Table 1
Compilation of the Empirical Literature

	Friedman Hypothesis		Countries	Data	Variables	Measure of uncertainty
	High ? causes > ? uncertainty	More ? unc, Lower output				
Della Mea U., Pena A. 1996	Positive	**	Uruguay	1973.01 – 1995.05	CPI	Granger Causality & ARCH (GARCH)
Crawford & Kasumovich 1996	Positive	**	Canada	1963.3-1994	CPI excluding food and effect of ind. taxes	GARCH
Magendzo, I., 1997.	Positive	**	Chile	1934-1997	CPI	ARIMA - GARCH
Grier K.B., Perry, M., 1998.	Positive	**	G7 Countries	1948 - 1993	CPI	GARCH & Granger
Ma, 1998	Positive	Supported	Colombia	1955-1997	CPI	GARCH and Granger causality
Fountas, 2000	Positive	Supported	U.K	1885-1998	CPI	ARCH (GARCH)
Grier and Grier	Positive	Supported	Mexico	1972.02 – 1997.05	CPI Industrial production	GARCH - M
Neyapti, 2000	Positive	Supported	Turkey	1982.10 – 1999.12	Wholesale price series	ARCH
Grier and Grier, 2003	Positive	Supported conditional on introduction of lag inflation	Mexico	1972:1-2001:12	CPI	VAR-GARCH-M
Elder, 2000	**	Supported	U.S	1966-1996	CPI	Identified VAR-MGARCH

3. Specification of the Econometric Model

In this section, I specify an econometric model that allows examining the effects of inflation uncertainty and exchange rate uncertainty on both output and exports. Additionally, I control and explore the possible consequences of monetary policy: the introduction of inflation targeting and the change of exchange rate regime from a targeted exchange rate to a flexible one.

I created a system of equations in which inflation, exchange rate, exports and output depend on lag values of each other. The first step is to specify a model to obtain both, inflation uncertainty and exchange rate uncertainty. Then, I analyze the effect of both of these variables on output and exports.

3.1. Model for Inflation Uncertainty.

For the estimation of inflation uncertainty I employed a GARCH (1,1)[4] model to generate a time-varying conditional variance of surprise inflation (measure of inflation uncertainty), it is an estimation of the variance of unpredictable innovations in the inflation rate. An ARCH model indicates that the variance of the error term is not constant over time and assumes that the conditional variance of the series depends on past realizations of the error process. The GARCH model generalizes the ARCH, allowing for both autoregressive and moving average components in the heteroskedastic variance. In terms of this paper, a specific model of inflation with conditional heteroskedasticity assumes that the conditional mean and variance of inflation are generated as follows:

$$?_t \; ? \; ?_0 \; ? \; \overset{l}{\underset{i?1}{?}} \; ?_i q_{t?i} \; ? \; \overset{l}{\underset{i?1}{?}} \; ?_1 ?_{t?i} \; ? \; \overset{l}{\underset{i?1}{?}} \; ?_i Y_{t?i} \; ? \; \overset{l}{\underset{i?1}{?}} \; ?_i X_{t?i} \; ? \; ?_t \qquad (1)$$

$$?_t \sim N(0, ?^2)$$

$$?^2_{?t} \; ? \; ?_0 \; ? \; ?_1 IT_{92} \; ? \; ?_2 EF_{99} \; ? \; ?_3 ?^2_{t?1} \; ? \; ?_4 ?^2_{?t?1} \; ? \; ?_5 ?_{t?1} \qquad (2)$$

Where p_t is the rate of inflation that depends on past values of itself, past values of the real exchange rate (q), past values of income (Y) and past values of exports (X) (the conditional mean of inflation)[5]. All this explanatory variables are contributing to the conditional mean of inflation. Furthermore, w_t is the error term that has conditional variance $?_{wt}^2$. The ARCH model was estimated by the method of maximum likelihood under the assumption that the errors are conditionally normally distributed.

Usually, GARCH (1,1) specifies that the conditional variance depends on three factors, a constant; the previous period's news about the variance of inflation which is taken to be the square residual from the previous period

4 ARCH models were first introduced by Engle (1982) and generalized as GARCH by Bollerslev. The concepts, procedures and derivations can be found in econometrics text books like Enders (2004) or Hamilton (1994)

5 Additionally, I included a budget deficit measure and an exogenous variable accounting for the change in oil prices but since they were not significant in any of the cases I excluded them from the equations.

(The ARCH term); and the previous period's forecast variance (the GARCH term). For the purpose of this research I have extended the equation to introduce two dummy variables: IT and EF. IT accounts for the period in which inflation targeting was first introduced by constitutional mandate into the economy, it takes the value of zero from 1980:1 to 1991:12, one for 1992:1 to 1999:8 and then zero again until 2003:12. Following Schmidt and Corbo (2001), EF accounts for the moment in which the Central Bank announced a movement towards a flexible exchange rate system. Hence, EF is equal to zero until 1999:8 and in 1999:9 it takes a value of one until then end of the sample.

Since this is a parametric model, GARCH estimation gives an explicit test of whether the movement in the conditional variance of inflation over time is statistically significant[6]. For the case of inflation, it has been shown that an important advantage of using this methodology is that it is highly correlated with other measures of uncertainty, such as measures based on survey data and disaggregated measures of price variability. Having a significant conditional variance one can estimate the model to test if it has any effect in output (Ma, 1998).

3.2. Model for Exchange Rate Uncertainty.

For the estimation of exchange rate uncertainty I followed a similar procedure to the one followed for inflation. I employed a GARCH (1,1) model to generate a time-varying conditional variance of exchange rate. The conditional mean and variance of the exchange rate are specified as follows:

$$q_t ? ?_0 ? \overset{l}{\underset{i?1}{?}} ?_i \, qi_1 ? \overset{l}{\underset{i?1}{?}} ?_i ?_{t?i} ? \overset{l}{\underset{i?1}{?}} ?_i Y_{t?i} ? \overset{l}{\underset{i?1}{?}} ?_i X_{t?i} ? ?_t \qquad (3)$$

$$?_t \sim N(0, ?^2)$$

$$?_{et}^2 ? ?_0 ? ?_1 IT_{92} ? ?_2 EF_{99} ? ?_3 ?_{t?1}^2 ? ?_4 ?_{?t?1}^2 ? ?_5 q_{t?1} \qquad (4)$$

Equation (3) describes the mean of exchange rate as a function of lagged values of itself, lags of inflation, lags of output and lags of exports.

6 Enders, W. (2004)

Equation (4) models the error variance of the exchange rate with one lag of the squared error and one lag of the variance, along with the dummy variables for the periods of inflation targeting and flexible exchange rate. I use this estimated variance as the time series measure of exchange rate uncertainty.

3.3 Model for Output, Exports, Inflation and Exchange Rate Uncertainty

In order to capture the theoretical underpinnings that I have stated along the paper, I propose a model for output growth and for exports as follows:

$$X_t ? ?_0 ? \overset{l}{\underset{i?1}{?}} E_i q_{t?i} ? \overset{l}{\underset{i?1}{?}} Z_i ?_{t?i} ? \overset{l}{\underset{i?1}{?}} H_i Y_{t?i} ? \overset{l}{\underset{i?1}{?}} ?_i X_{t?i} ? ?USY_t ? M?_{?t} ? ? ?_{?t} ? ?IT_{92} ? T_{99} ? ?_{15} Oil ? ?_t \quad (5)$$

$$Y_t ? ?_0 ? \overset{l}{\underset{i?1}{?}} ?_i q_{t?i} ? \overset{l}{\underset{i?1}{?}} ?_i ?_{t?i} ? \overset{l}{\underset{i?1}{?}} ?_i Y_{t?i} ? \overset{l}{\underset{i?1}{?}} ?_i X_{t?1} ? ?USY_t ? ?? _{?t} ??? _{?t} ? AIT_{92} ? BEF_{99} ? ?_{15} Oil ? ?_t \quad (6)$$

Equation (5) and (6) describe the models for real exports and real output as a function of their own lags, lags of real exchange rate, lags of inflation, lags of output, U.S. output, oil prices[7]. Both equations are also a function of the conditional variance of inflation and the conditional variance of real exchange rate (measured as the standard deviation of their conditional variance).

For the purpose of this paper, the important coefficients are the ones on the effect that lagged inflation, lagged exchange rate, inflation and exchange rate uncertainty on both exports and output. Also, I want to examine if there is any significance of the dummy variables IT and EF on the conditional variance of inflation and real exchange rates in order to extract conclusions about the introduction of inflation targeting and exchange rate float systems.

4. Data Analysis

This section presents the analysis of the econometric model and starts by testing for the existence of conditional heteroskedasticity in inflation and exchange rates. I use monthly data from 1980:1 through 2003:12 on Colombian consumer prices (CPI) to obtain inflation, industrial production

[7] Given the importance of U.S economy to Colombia (U.S.) being the major partner; I included U.S Industrial Production. Oil prices are included as they are expected to affect the economy.

(IP) as a measure of output. Total exports (X), Oil prices and real exchange rates (q). Consumer prices and the real exchange rate are obtained from the IMF's International Financial Statistics CD-ROM, while the other variables are from the Central Bank of Colombia and DANE. Data on U.S. industrial production, U.S. CPI and Oil prices are taken from the St. Louis Federal Reserve "FRED" online database[8].

The first step in this section is an estimation of the conditional variances for inflation and exchange rates. They will be the measures of uncertainty. I checked for the appropriate number of lags that each variable needed per equation. That is how many lags of exchange rates, inflation, industrial production and exports do we need to include in the mean equations of exchange rate and inflation. This procedure was based on the SIC criterion[9] by setting a maximum of 7 lags and doing all possible combinations that minimized the criterion. The estimation of each equation was done in levels to avoid issues of cointegration between variables (See Granger and Engel (1987)).

5.1 Existence of Conditional Heteroskedasticity

5.1.1 Inflation and Inflation Uncertainty

The estimated mean equation for inflation contained two lags of the exchange rate, two lags of inflation, two lags of exports and one lag for output.[10] The results are as follows:

$$?_t = -0.012 - 0.009q_{t-1} + 0.01q_{t-2} + 0.443\ ?_{t-1} + 0.089\ ?_{t-2} + 0.016\ Y_{t-1} -0.003\ X_{t-1} + -0.006\ X_{t-2} + ?_t$$

(-1.312) (-2.573) (2.226) (5.490) (1.249) (3.984) (-1.321) (-2.919)

To make sure that there is no serial correlation among residuals, the Box Pierce Q-statistic was checked. The Q statistic indicated that the equation residuals are free of serial correlation. A Lagrange multiplier test was used to detect the presence of conditional volatility in the equation residuals. The LM-ARCH test for conditional heteroskedasticity was estimated at lags 1, 4,

8 See Data appendix for more detail.

9 SIC criterion was chosen over the AIC because the AIC tends to select a model with larger criteria and, by the principle of parsimony, we prefer a model with less parameters.

10 Z-statistics are in parenthesis. D-W, R2 and other details are presented in the appendix, Table 1A

8 and 12. In all cases the null hypothesis of no ARCH was rejected. Thus, the conditional variance of inflation is a relatively persistence process. The results for conditional variance are:

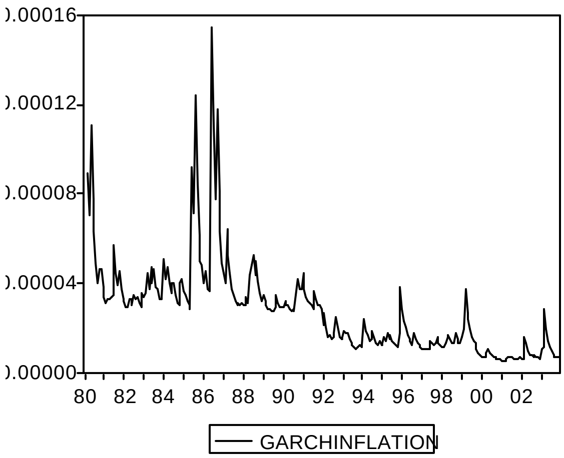
$$?^{2}_{?t} = 1.05E\text{-}05 \;\; - 6.51E\text{-}06\, IT_{92} + -8.39E\text{-}06\, EF_{99} + 0.149\; ?^{2}_{t-1} + 0.599 s^{2}_{?t-1}$$

(1.748) (-1.533) (-1.679) (2.666) (3.359)

As the results indicate, both the ARCH and GARCH parameters are significant. The dummy for IT is not significant and the dummy EF is significant only at the 10% level. This would indicate that uncertainty about inflation was not strongly impacted by these two changes in the economy.

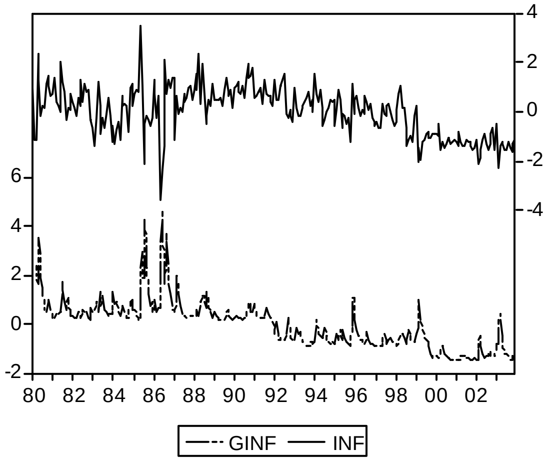
Graph 1 shows the extracted measure of inflation uncertainty. There are three periods when inflation uncertainty was particularly high: the early 1980s, 1985 and 1986-7. These three periods coincide with the Latin-American hyperinflation crises, the international crises and heavy currency speculation. It is evident graphically that, starting the 1990s; inflation uncertainty has decreased substantially.

Graph 1



By comparing inflation levels and its conditional variance, we can see in Graph 2 that high inflation levels do not necessarily mean higher levels of uncertainty but, instead, abrupt changes are the ones that create more uncertainty.

Graph 2



5.1.2 Exchange Rates and Exchange Rate Uncertainty

The mean equation of exchange rate and its conditional variance were estimated in levels. The number of lags was chosen minimizing the SIC criterion and the final model was composed of two lags of the exchange rate, two of industrial production, and one lag for exports and inflation.[11]

$$q_t = 1.248q_{t-1} - 0.244q_{t-2} + 0.145\ ?_{t-1} + 0.010\ Y_{t-1} - 0.032\ Y_{t-2} + 0.012\ X_{t-1} + ?_t$$

(15.701) (-3.078) (1.149) (0.616) (-1.727) (2.723)

A Lagrange multiplier test was used to detect the presence of conditional volatility. The LM-ARCH test for conditional heteroskedasticity was estimated at lags 1, 4 and 8 and 12. In all cases the null hypothesis of no ARCH was rejected. The conditional variance is specified as follows:

$$?^2_{et} = 8.11E\text{-}05 + 0.002\ IT_{92} + 0.001\ EF_{99} + 0.538\ ?^2_{t-1} + 0.321\ s^2_{?t-1}$$

(2.714) (4.035) (1.775) (7.321) (3.191)

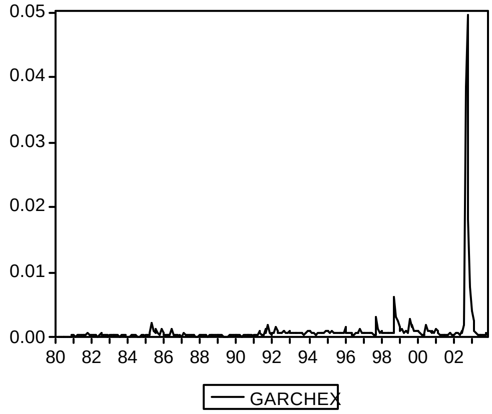
To make sure that there was no serial correlation among residuals, the Box Pierce Q-statistic was checked and indicated that the residuals are free of serial correlation. Both the ARCH and GARCH parameters are significant. The dummy for IT is significant while EF is not significant. This result is

11 Z-statistics are in parenthesis. D-W, R2 and other details are presented in the appendix, Table 2A

somewhat unexpected since we would expect the movement towards flexible exchange rates would be more significant in explaining uncertainty. However, the early 1990s coincide as well with the opening of the economy to the world market and this might have been a more important impact on the behavior of the exchange rate.

Graph 3 indicates a mild period of uncertainty during the mid eighties and an increasing uncertainty during the end of the nineties. Recalling the history of Colombia, 1999 was the year of a change from target bands for exchange rates to a flexible exchange. Year 2003 represents a big outlier.

Graph 3



Next, I present an analysis of whether inflation volatility has affected real economic activity, and whether the effect is statistically and economically significant.

5.1.3 Effects of Uncertainty on Output.

To analyze the effects of uncertainty on output, I regressed output on all the variables of the system with the number of lags as indicated by the SIC criterion. The first equation contains all the variables and as we can see, the coefficient on exchange rate uncertainty is not significant.[12] Exchange rate uncertainty (GEX = ?$_{?}$) and inflation uncertainty (GINF = ?$_{?}$) were left into

[12] Since the two dummy variables and oil prices were insignificant, they were removed from the final equation

the equation as a matter of comparison. The equation displays evidence that uncertainty about the exchange rate is not significant explaining output. The results are as follows[13]:

$$Y_t = 0.486 - 0.032q_{t-1} - 0.043?_{t-1} + 0.261Y_{t-1} + 0.368Y_{t-2} + 0.299Y_{t-3} + 0.002X_{t-1} - 0.009GEX_t - 3.439GINF_t + ?_t$$

(3.564) (-3.092) (-0.142) (4.372) (6.741) (5.339) (0.157) (-0.099) (-2.379)

The equation was estimated again taking away all the variables with insignificant coefficients and the results were:[14]

$$Y_t = 0.476 - 0.032\,q_{t-1} + 0.263\,Y_{t-1} + 0.370\,Y_{t-2} + 0.300\,Y_{t-3} - 3.562\ GINF + ?_t$$

(3.676) (-3.107) (4.647) (6.836) (5.388) (-2.627)

The Q-statistic indicates no serial correlation among the errors. As relevant variables only exchange rates, past levels of output and uncertainty about inflation are significant. These results are in line the usual theoretical expectation that inflation uncertainty will deteriorate output.

5.1.4 Effects of Uncertainty on Exports.

The estimates of exports contain all the variables of the system with the lags as indicated by the SIC criterion. The estimated equation shows that none of the measures of uncertainty are significant in explaining exports.

The results of the equation are as follows[15]:

$$X_t = -1.456 - 0.068\,q_{t-1} - 0.733\,?_{t-1} + 0.925?_{t-2} - 3.077\,?_{t-3} + 0.417\,Y_{t-1} + 0.215\,X_{t-1} + 0.191\,X_{t-2} + 0.210\,X_{t-3}$$

(-2.102) (-1.495) (-0.462) (0.556) (-1.990) (3.028) (3.546) (3.221) (3.583)

$$+ 0.528\,LYUSA_t + 2.555GINF_t - 0.132GEX_t + ?_t$$

(3.523) (0.386) (-0.310)

A new regression indicates the only significant variables explaining the behavior of exports are past values of itself, past values of income, and U.S. income[16].

$$X_t = -2.093 + 0.419\,Y_{t-1} + 0.222\,X_{t-1} + 0.194\,X_{t-2} + 0.212\,X_{t-3} + 0.576LYUSA_t + ?_t$$

(-4.631) (3.627) (3.661) (3.289) (3.623) (4.608)

13 t-statistics are in parenthesis. D-W, R2 and other details are presented in the appendix, Table 3A

14 t-statistics are in parenthesis. D-W, R2 and other details are presented in the appendix, Table 4A

15 t-statistics are in parenthesis. D-W, R2 and other details are presented in the appendix, Table 5A

16 t-statistics are in parenthesis. D-W, R2 and other details are presented in the appendix, Table 6A

5.1.5 Does Inflation Granger causes Uncertainty?

Empirical studies establishing the relationship between inflation and inflation uncertainty have also attempted to do the analysis of causality (This has been stated as the "Friedman hypothesis", now extended to "Friedman-Ball" hypothesis). Most of these studies have concentrated mainly on how to measure inflation uncertainty and on how to establish causality tests between this latter and inflation.[17] Results of past studies are not completely conclusive but, in most of the cases, the results tend to show a positive relationship between inflation and inflation uncertainty, running in the direction proposed by Friedman: high rates of inflation cause more uncertainty.

Since we have determined that it is uncertainty that lowers output, it is of interest to analyze if more inflation leads to more uncertainty. This is a relevant issue since it will allow the determination of how relevant is the implementation of inflation targeting. If inflation targeting reduces inflation and it's inherent uncertainty, then we will expect that it is good because it would not only create and environment of price stability, but also an environment for improvement in output and economic growth.

The Granger approach specifies whether inflation causes inflation uncertainty, by analyzing how much of current inflation can be explained by past values of inflation and lagged values of our measure of inflation uncertainty. Inflation is said to Granger-caused by inflation uncertainty if inflation uncertainty helps in the prediction of inflation. In this case I will analyze both ways of causation.

The test was evaluated with an F-test of joint hypothesis at lag one, four, eight and twelve. According to the results, we reject both hypotheses that inflation uncertainty does not cause inflation and vice versa. Therefore we conclude that, in the case of Colombia, there is bi-directional causality between inflation and inflation uncertainty.

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[17] See Della Mea U., Pena A. 1996.

Table 3

Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Probability
Lags: 1			
GINF does not Granger Cause INF	285	13.0771	0.00035
INF does not Granger Cause GINF		4.59723	0.03288
Lags: 4			
Null Hypothesis:	Obs	F-Statistic	Probability
GINF does not Granger Cause INF	282	4.72141	0.00106
INF does not Granger Cause GINF		3.91706	0.00413
Lags: 8			
Null Hypothesis:	Obs	F-Statistic	Probability
GINF does not Granger Cause INF	278	2.23668	0.02527
INF does not Granger Cause GINF		2.75049	0.00624
Lags: 12			
Null Hypothesis:	Obs	F-Statistic	Probability
GINF does not Granger Cause INF	274	1.71950	0.06309
INF does not Granger Cause GINF		2.95363	0.00073

6. Conclusion

This paper considers the effects of uncertainty about inflation and exchange rates on real economic activity controlling for structural changes in monetary policy. Therefore it explores both the "regime uncertainty" and "certainty equivalence" explanations that have been proposed on the literature.

The results indicate that neither uncertainty about inflation nor uncertainty about exchange rates were significantly impacted in the IT and EF periods, meaning that uncertainty might be an ongoing process and a result of many other causes. It is important to note that only uncertainty about inflation has effects on output. According to the empirical evidence, there is support to suspect that increases in uncertainty about inflation do decrease levels of output. On the other hand, uncertainty about the exchange rate does not have effects on either exports or output.

As a last remark, it is important to note that inflation Granger causes uncertainty and vice versa. This might be an indication contradicting the usual belief that high but stable inflation does not cause uncertainty. More research is still needed in this area, a systematic study that involves other variables and the experience of other countries (small open economies) might enlighten the real advantages that inflation targeting has.

8. References

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7. Data Appendix

Monthly Data, (1980:1 – 2003:12).

Consumer price index and nominal exchange rate are from the IMF, IFS-CDROM. Exports and Industrial Production are from the Central Bank of Colombia (Banco de la República, DANE). Consumer price index of the Unites States, Industrial Production for the U.S and Oil Prices are from the FRED, Federal Reserve Bank of St. Louis. All variables except the nominal exchange rate and oil prices are seasonally adjusted (Census X11 multiplicative procedure). Variables definitions and IMF-IFS CD-ROM are as follow:

Consumer price index (CPI):	Code: 23364...ZF
Consumer Price (CPIUSA)[18]:	S.A. From: U.S. Department of Labor: Bureau of Labor - Index 1982-84 = 100
Industrial Production (IP)[19]:	DANE, Banco de la República. Indexm: 1990 = 100
Official exchange rate (ER):	IMF National Currency per SDR. Code: 233..AA.ZF.
Real Exchange Rate (RER):	IMF Code: 234..AA.ZF.
Total Exports[20]:	DANE, Banco de la República. (Millions of US$)
Oil Prices[21]:	Dollars per Barrel, Reprinted with permission from Dow Jones Energy Service. Copyright
Industrial Production U.S. (IPUS):	S.A.G.17 Industrial Production and Capacity Utilization Index 1997 = 100

18 In: http://research.stlouisfed.org/fred2/series/CPIAUCSL/9

19 In: http://www.banrep.org/economia/estad4.htm

20 In: http://www.banrep.org/economia/estad4.htm

21 In:http://research.stlouisfed.org/fred2/series/OILPRICE/downloaddata

8. Appendix 1A

Table 1A

Dependent Variable: INF Method: ML – ARCH				
	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.012435	0.009477	-1.312117	0.1895
LRER(-1)	-0.009936	0.003862	-2.573005	0.0101
LRER(-2)	0.010089	0.004532	2.226301	0.0260
INF(-1)	0.443180	0.080719	5.490392	0.0000
INF(-2)	0.089734	0.071824	1.249366	0.2115
LY(-1)	0.016135	0.004049	3.984408	0.0001
LX(-1)	-0.002941	0.002226	-1.321095	0.1865
LX(-2)	-0.005823	0.001995	-2.919538	0.0035
		Variance Equation		
C	1.05E-05	6.03E-06	1.748104	0.0804
ARCH(1)	0.148856	0.055821	2.666686	0.0077
GARCH(1)	0.599148	0.178358	3.359237	0.0008
IT	-6.51E-06	4.25E-06	-1.533230	0.1252
EF	-8.39E-06	5.00E-06	-1.679083	0.0931
R-squared	0.479584	Mean dependent var		0.015093
Adjusted R-squared	0.456709	S.D. dependent var		0.007190
S.E. of regression	0.005300	Akaike info criterion		-7.806391
Sum squared resid	0.007668	Schwarz criterion		-7.640210
Log likelihood	1129.314	F-statistic		20.96503
Durbin-Watson stat	2.041039	Prob(F-statistic)		0.000000

Table 2A

Dependent Variable: LRER Method: ML – ARCH				
	Coefficient	Std. Error	z-Statistic	Prob.
LRER(-1)	1.248083	0.079488	15.70162	0.0000
LRER(-2)	-0.244305	0.079362	-3.078354	0.0021
INF(-1)	0.145146	0.126306	1.149162	0.2505
LY(-1)	0.010890	0.017672	0.616248	0.5377
LY(-2)	-0.032087	0.018578	-1.727105	0.0841
LX(-1)	0.012044	0.004422	2.723601	0.0065
	Variance Equation			
C	8.11E-05	2.99E-05	2.714134	0.0066
ARCH(1)	0.538109	0.073498	7.321409	0.0000
GARCH(1)	0.321273	0.100668	3.191401	0.0014
IT	0.000209	5.18E-05	4.035048	0.0001
EF	0.000138	7.78E-05	1.775759	0.0758
R-squared	0.986667	Mean dependent var		4.660179
Adjusted R-squared	0.986182	S.D. dependent var		0.260151
S.E. of regression	0.030581	Akaike info criterion		-4.793355
Sum squared resid	0.257177	Schwarz criterion		-4.652740
Log likelihood	696.4498	Durbin-Watson stat		2.414384

Table 3A

Dependent Variable: LY Method: Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.486163	0.136401	3.564208	0.0004
LRER(-1)	-0.032137	0.010393	-3.092270	0.0022
INF(-1)	-0.043518	0.306653	-0.141913	0.8873
LY(-1)	0.260882	0.059662	4.372654	0.0000
LY(-2)	0.368459	0.054656	6.741466	0.0000
LY(-3)	0.299322	0.056066	5.338764	0.0000
LX(-1)	0.001531	0.009740	0.157232	0.8752
GEX	-0.009569	0.096777	-0.098872	0.9213
GINF	-3.438730	1.445392	-2.379099	0.0180
R-squared	0.971843	**Mean dependent var**		4.561749
Adjusted R-squared	0.971027	**S.D. dependent var**		0.177701
S.E. of regression	0.030247	**Akaike info criterion**		-4.127741
Sum squared resid	0.252514	**Schwarz criterion**		-4.012399
Log likelihood	597.2031	**F-statistic**		1190.764
Durbin-Watson stat	1.974147	**Prob(F-statistic)**		0.000000

Table 4A

Dependent Variable: LY Method: Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.476339	0.129582	3.675957	0.0003
LRER(-1)	-0.031768	0.010224	-3.107070	0.0021
LY(-1)	0.263114	0.056621	4.646961	0.0000
LY(-2)	0.369508	0.054051	6.836348	0.0000
LY(-3)	0.299881	0.055649	5.388811	0.0000
GINF	-3.562004	1.355774	-2.627284	0.0091
R-squared	0.971834	**Mean dependent var**		4.561749
Adjusted R-squared	0.971329	**S.D. dependent var**		0.177701
S.E. of regression	0.030089	**Akaike info criterion**		-4.148490
Sum squared resid	0.252591	**Schwarz criterion**		-4.071595
Log likelihood	597.1598	**F-statistic**		1925.329
Durbin-Watson stat	1.973665	**Prob(F-statistic)**		0.000000

Table 5A

Dependent Variable: LX Method: Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-1.456146	0.692613	-2.102396	0.0364
LRER(-1)	-0.067873	0.045404	-1.494879	0.1361
INF(-1)	-0.733046	1.585043	-0.462477	0.6441
INF(-2)	0.924630	1.663585	0.555806	0.5788
INF(-3)	-3.077107	1.546608	-1.989585	0.0476
LY(-1)	0.417103	0.137748	3.028008	0.0027
LX(-1)	0.215589	0.060804	3.545612	0.0005
LX(-2)	0.191219	0.059362	3.221233	0.0014
LX(-3)	0.210531	0.058760	3.582901	0.0004
LYUSA	0.528120	0.149889	3.523407	0.0005
GINF	2.555110	6.626356	0.385598	0.7001
GEX	-0.131509	0.424762	-0.309607	0.7571
R-squared	0.940065	**Mean dependent var**		6.326137
Adjusted R-squared	0.937650	**S.D. dependent var**		0.527558
S.E. of regression	0.131731	**Akaike info criterion**		-1.174920
Sum squared resid	4.737368	**Schwarz criterion**		-1.021131
Log likelihood	179.4261	**F-statistic**		389.2690
Durbin-Watson stat	2.038118	**Prob(F-statistic)**		0.000000

Table 6A

Dependent Variable: LX Method: Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-2.093378	0.452082	-4.630527	0.0000
LY(-1)	0.418952	0.115504	3.627154	0.0003
LX(-1)	0.222039	0.060643	3.661400	0.0003
LX(-2)	0.193647	0.058877	3.289000	0.0011
LX(-3)	0.212174	0.058559	3.623245	0.0003
LYUSA	0.576054	0.125009	4.608115	0.0000
R-squared	0.938627	**Mean dependent var**		6.326137
Adjusted R-squared	0.937527	**S.D. dependent var**		0.527558
S.E. of regression	0.131861	**Akaike info criterion**		-1.193307
Sum squared resid	4.851072	**Schwarz criterion**		-1.116413
Log likelihood	176.0463	**F-statistic**		853.3916
Durbin-Watson stat	2.028086	**Prob(F-statistic)**		0.000000