Nonlinearities and the nexus between inflation and inflation uncertainty in Egypt: New evidence from wavelets transform framework

Jamal Bouoiyour and Refk Selmi

CATT, University of Pau, ESC, High School of Trade of Tunis

November 2013

Nonlinearities and the nexus between inflation and inflation uncertainty in Egypt: New evidence from wavelets transform framework

Prepared by :

Jamal Bouoiyour[1] and Refk Selmi[2]

Abstract : How does inflation uncertainty interact with inflation rate? The purpose of this article is to assess this question in Egypt in a wavelets transform framework. We investigate the direction of causality in the relationship inflation-inflation uncertainty by combining component GARCH model, wavelets decomposition and scale-by-scale nonlinear causality test. We find a strong evidence in favor of Friedman-ball hypothesis in both time domain and the different frequencies. This study succeeds to resolve the inconsistencies and to point a robust nonlinear effect of inflation on inflation uncertainty, which is more intense at high frequency bands than at low ones. We attribute this result to the complexity in predicting how strongly and how quickly prices will respond to monetary policy, the asymmetry between inflation booms and recessions, the incidence of exogenous shocks, the co-movement of permanent shocks with inflation and the downward expectations of monetary authorities.

Keywords: Inflation, inflation uncertainty, GARCH, wavelets, nonlinear causality.

JEL Codes : E3 ; C1 ; C6.

[1] CATT, University of Pau.

[2] ESC, High School of Trade of Tunis. s.refk@yahoo.fr

1. Introduction

The climate of high inflation was brought monetary authorities to worry about the possible effects of its uncertainty on economic activities. The inflation uncertainty can cloud the decisions of policymakers and reduce then economic well-being. This subject has caught great attention either theoretically or empirically since the study of Friedman (1977). This latter was the first to suggest that higher average inflation increases inflation uncertainty. Accordingly, the same idea was developed then by Ball (1992) by exploring a restricted-model, showing that higher inflation leads to an increase in inflation uncertainty over the monetary policy stance.

Inflation rate is a key determinant of economic decisions. Ups and down inflation movements can affect widely the decisions of businesses and consumers, leading to an uncertainty about inflation (described by analysts as ex ante). Inflation yields also to an uncertainty about other variables that are heavily important in monetary decisions (described by analysts as ex post). This creates a need to elucidate the understanding of policymakers about the focal relationship.

Several researches have been done on the linkage between inflation and inflation uncertainty using different proxies for uncertainty but up to now the area stills inconclusive. Studies who estimate inflation uncertainty from survey data show that the uncertainty about inflation rises with its level (Holland, 1993). However, the findings from restricted-uncertainty models are ambiguous (Devereux, 1989) and the results from models linking exchange rate with the nexus between inflation and its uncertainty suggest insignificant linkage at all (Golob, 1994). This study takes another look at the evidence while trying to reconcile this disagreement. Because causalities between inflation and inflation uncertainty are relevant for monetary policy (Fountras, 2001; Hartman and Herwartz, 2012).

In this article, we choose Egypt as case of study because in our knowledge there is only one research assessing this link in this country (Achour and Trabelsi, 2011). Using the state-space model with Markov switching specification and the local level model with standard GARCH, they conclude that there is a positive and significant link between both variables that runs from inflation uncertainty to inflation in the short run and dies out in the long run, which attribute it to the stabilization monetary policy in Egypt. We thought to revisit the focal nexus because we cannot assume that this result is conclusive for three main reasons: (i) Inflation dynamics is subject to transitory and permanent shocks, which in turn are subject to switching between calm and volatile regimes. Because Egypt has undergone several shocks, it seems important to verify whether transitry or permanent effects co-move positively with inflation and which shock link stronger to inflation. (ii) Monetary authorities have different objectives determined stochastically over time that lead to a trade-off between expanding output in favor of creating monetary surprises that raise uncertainty about inflation yielding then to a larger inflation costs. It seems then crucial to evaluate this relationship depending to frequency-by-frequency variation ; (iii) The step taken toward decreased central bank independence of Egypt in 2003 (Bouoiyour and Selmi, 2013) and the rapid increase in domestic credits during this period lowered the effectiveness of the stabilization policy. Alternatively, in low CBI economies as Egypt, the actions of policymakers can engender an instable macroeconomic environment which in turn can create a controversial linkage between inflation and its uncertainty. This creates a need to account time scales variation.

To resolve the inconsistencies and to point a robust relationship between inflation and inflation uncertainty, our work fills the void by extending the issue in two directions. Firstly, Instead of standard deviation or variance of inflation, conditional volatility is used as proxy for inflation uncertainty. To verify whether transitory or permanent effects co-move significantly with inflation and which shock link stronger to inflation, we use component GARCH model to generate conditional volatility of the inflation series. Secondly, to check whether the nexus between inflation and its uncertainty varies under different frequencies, we apply the scale-by-scale nonlinear causality test in a Morlet framework.

The remainder of the paper is divided in six sections: The second section presents a brief theoretical and empirical background on the link between inflation and inflation uncertainty. Section 3 is a brief overview of the main monetary policy developments since 1990. Section 4 presents our methodological framework. We discuss then in section 5 our empirical findings and the main economic implications. Section 6 concludes.

2. Inflation-inflation uncertainty nexus: Brief theoretical background

The nexus between inflation and inflation uncertainty have been an issue in international economics for the past 40 years. Inflation costs have been and continue to be the most researched topic in macroeconomics on empirical front. Studies in this field propose four hypothesis for the possible outcomes of causality:

(i) Friedman-Ball hypothesis (Friedman (1977) and Ball (1992)) suggests that there is an unidirectional and positive link that runs from inflation to inflation uncertainty. This implies that a stable inflation degenerates inflation uncertainty which in turn can improve economic performance of each economy. Brunner and Hess (1993) and Grier and Perry (1998) show a significant link from inflation level to its uncertainty. Earlier, Karanasos and Stefanie (2008) test the alternative hypothesis for Germany, Netherlands and Sweden and checked it for the three countries; (ii) Cukierman and Meltzer hypothesis (Cukierman and Meltzer, 1986) put strong evidence that inflation uncertainty increases inflation rate. Baillie et al. (1996) support this hypothesis for United Kingdom. Accordingly, by carrying out GARCH model to measure uncertainty, Zeynel and Mahir (2008) show a strong evidence of Cukierman-Meltzer hypothesis for Jordan, Philippines and Turkey; (iii) Devereux hypothesis (Devereux, 1989) suggests that inflation uncertainty can affect inflation rate negatively and positively. Arguably, Grier et al. (2004) and Karanasos et al. (2004), using standard GARCH model in the case of United States, confirm that there is a controversial link between the two variables; (iv) Feedback hypothesis or Holland hypothesis (Holland, 1993) suggests that an increase in inflation uncertainty can bring a drop in inflation rate as an outcome of the stabilization policy pursued when there is an excessive volatile inflation rate. Grier and Perry (1998) support Holland hypothesis in United States and Germany where higher inflation uncertainty prompts lower inflation.

Table 1 provides a detailed review of literature on the focal relationship. We note that studies on the nexus between inflation and inflation uncertainty are scarce and controversial. Most studies on this topic emphasize this link in developed countries, while analyses across developing countries are virtually absent.

A large strand of literature investigate the relationship between inflation and inflation uncertainty in a linear setting (see for instance, Okun (1971), Friedman (1977), Golub (1994), Baillie et al. (1996), among others). Other stream of literature use game models such as Barro-Gorden model and Asymmetric information game specification (for example, Devereux (1989), Ball (1992) and Holland (1993) to check the friedman hypothesis. Few studies allow for nonlinearities in debt effects on economic growth using different method including nonparametric causality tests and Markov switching model (see for example, Ricketts and Rose (1995), Balcilar et al. (2011) and Achour and Trabelsi (2011)). By doing so, they find that there is no well-specified model that can generate effectively and lead to conclusive findings on the nexus between inflation and its uncertainty.

Indeed, the nexus between inflation and inflation uncertainty seems inconclusive. As reported in the Table mentioned below, the mixed results may be highly conditional to authors' modeling strategies, the nature of countries and the context of authors' investigations. It appears also that researches on this field are most likely to support Friedman-Ball hypothesis.

Table 1. A literature survey on the nexus between inflation and its uncertainty

Study	Studied countries	Model	Hypothesis
Okun (1971)	Panel of 17 OECD countries	Standard deviation and parametric causality test.	Countries with high average inflation display inflation uncertainty.
Friedman (1977)	G7 countries : i.e. Canada, France, Germany, Italy, Japan, United Kingdom and United States.	Standard average deviation and Granger causality test.	A rise in the average rate of inflation prompts more uncertainty about inflation.
Cukierman and Meltzer (1986)	France, Italy, Japan, Spain.	Game-theoretic model	Central Banks create inflation surprises when there is a great uncertainty about inflation.
Bollerslev (1986)	United States.	GARCH model	The conditional variance of inflation is lower when inflation level is highest.
Pourgerami and Maskus (1987)	07 Latin American countries.	Standard deviation and Granger causality test	A rise in inflation increases ressources'investment in forecasting inflation leading then to a drop of inflation uncertainty.
Devereux (1989)	Germany, Hungray, Indonesia, Korea, Netherlands, Sweden.	Barro-Gorden model	The inflation uncertainty can have an adverse effect on inflation.
Ball (1992)	G7 countries	Asymmetric information game model	Formal derivation of Friedman hypothesis
Cukierman (1992)	France, Japan, Germany, United States.	OLS with interactive terms	Central bank independence plays an important role in how interacts inflation level to its uncertainty.
Holland (1993)	Columbia, Germany, Hungray, Indonesia, Israel, Korea, Mexico, Netherlands, Sweden and Turkey.	Barro-Gorden model	The inflation uncertainty can have a positive impact on inflation via real uncertainty canal.
Golub (1994)	United States	Parametric causality test	Positive effect of inflation on inflation uncertainty.
Joyce (1995)	United Kingdom	GARCH model	Inflation uncertainty is more sensitive to positive inflation shocks than negative ones.
Ricketts and Rose (1995)	Canada	Markov-switching model	Inflation uncertainty increases widely during high inflation periods.
Baillie et al. (1996)	United Kingdom	ARCH model and linear causality test	Evidence in favor of Cukierman and Meltzer hypothesis above mentioned.

Grier and Perry (1998)	G7 countries	GARCH model and parametric causality test.	Unidirectional link that runs from inflation uncertainty to the level of inflation rate.
Nas and Perry (2000 a)	G7 countries	GARCH model	The changing in policymakers behaviour toward inflation can precipate the time-varying in the structure of inflation.
Nas and Perry (2000 b)	Turkey	Standard deviation and linear causality test	Inflation rate increases inflation uncertainty.
Grier and Perry (2000)	France, Germany, Japan, United Kingdom and United States.	GARCH model and parametric causality test.	Significant bidirectional link between inflation and inflation uncertainty.
Neyapti and Kaya (2001)	Turkey	ARCH model and parametric causality tests.	Unidirectional link that runs from inflation level to its uncertainty.
Foutnas et al. (2003)	France, Germany, Italy, Netherlands and Spain.	GARCH model.	A joint feedback between the mean and the conditional variance of inflation.
Foutnas and Karanasos (2004)	France, Germany, Japan, United Kingdom and United States.	GARCH model and parametric causality test.	Support of feedback hypothesis.
Kontanikas (2004)	United Kingdom.	GARCH model.	The adoption of inflation targeting reduces the long-run effect of inflation uncertainty on the level of inflation rate.
Elder (2004)	Euro area.	GARCH model and VAR specification.	The linkage between inflation and inflation uncertainty depends intensely to studied time periods.
Bhar and Hamori (2004)	G7 countries.	Markov switching model	The relationship between inflation and its uncertainty depends considerably on whether the shock is transitory or permanent and differs depending to countries’characteristics.
Thornton (2008)	Argentina.	GARCH model.	Evidence in accordance with that of Friedman-Ball hypothesis.
Zeynel and Mahir (2008)	Jordan, Philippines, Turkey.	GARCH model.	Strong evidence in favor of Friedman-Ball hypothesis and weak evidence in accordance with Cukierman and Meltzer (1986).
Corporale et al. (2010)	Panel of European countries.	GARCH model and VAR framework.	In the euro period, the European Central Bank can achieve lower inflation uncertainty by lowering inflation rate.
Achour and Trabelsi (2011)	Egypt.	The state-space model with Markov switching heteroskedasticity.	Inflation uncertainty has a positive effect on inflation level in the short run but this effect dies out in the long run.
Balcilar et al. (2011)	Japan, United Kingdom and United States.	GARCH model and nonparametric causality test.	Inflation and inflation uncertainty have a positive predictive content for each other, which is in accordance

			therefore to the Friedman and Cukierman-Meltzer hypotheses, respectively.
Hermann et al. (2012)	Panel of 22 emerging countries.	GARCH model and cointegration framework.	The nexus between inflation and its uncertainty is highly conditional to the degree of central bank independence.
Hachicha and Lean (2013)	Tunisia.	GARCH-in-mean and linear Granger causality test.	Inflation uncertainty has a positive and significant effect on inflation rate.
Bouoiyour and Selmi (2013 b)	Panel of 12 emerging countries.	GMM model with interactive terms.	Countries with high level of central bank independence and chosen pegged exchange regime as exchange policy tend to exhibit low and stable inflation.

Source: Authors'compulation.

3. Brief overview of monetary policy developments

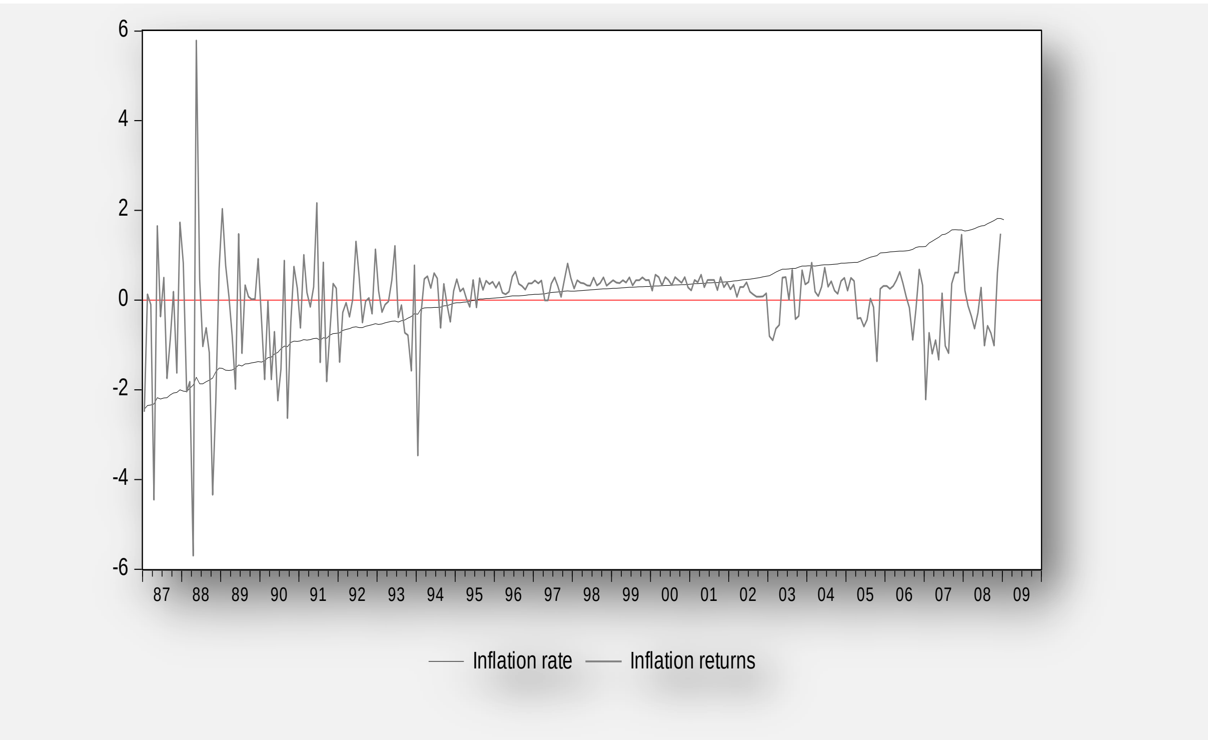
Since 1990, the Egyptian exchange rate has undergone numerous shocks such as the East Asian crisis and Luxor terrorist attack in 1997, the fall of oil prices in 1998 and the revival of tensions in the Middle East peace process in the end of 90's. These latter led to capital outflows, a slowdown in the capital market, a deterioration of the current account balance and a slowdown in tourism sector and economic growth (e.g. Kandil and Nergiz (2008) and Bouoiyour and Selmi (2013 a)). Then and from 2001, the aftermath of the New York terrorist attack and the subsequent wars on Afghanistan and Iraq darkened the investment's attractiveness of Egypt. The above events put Egypt government under pressure. Despite this, the Egyptian Central Bank does not use monetary policy tools to respond quickly and effectively to these numerous shocks. Arguably, Panizza (2001) explains the behavior of monetary authorities during this period by the fact that Egypt was unwilling to have a market-determined pegged exchange rate, intensely due to the fear of a pass-through effect.

These economic circumstances lead Egypt to apply an economic reform and structural adjustment program which has as ultimate goal to maintain price stability (Abu-Elayoum, 2003). However, the implementation of a new law governing the banking sector in 2003 yields to a change in the main monetary policy objective (Awad, 2008). The new framework does not focus only the achievement of stable inflation outcomes but relies also on the use of the overnight interest rate on interbank transactions as monetary policy target.

We depict in Figure 1 that the inflation surged quickly in the whole period (see Figure 1). This is mainly due to the geopolitical tension such as the Iranian-Iraqian wars in 1988 and Gulf war 1990-1991. In the early 2000s, we note that the inflation rate is almost stable. Thereafter and particularly since 2002, we observe clearly that inflation start to increase widely. This may be explained by exogenous shocks to the region, such as American-Iraqian tension in 2003, which led to higher price for oil that can translate to other commodity prices on international market and then to exchange rates reflecting stronger demand in Egyptian case. Hence, the adopted monetary policy apparently failed to reduce the continuous increase in inflation rate and the excessive exchange rate returns.

At this stage, it remains crucial to elucidate understanding on the real reaction of inflation rate on the actions of policymakers requires a need to investigate carefully the connection between inflation and its uncertainty. This remains our main objective throughout the rest of the article.

Figure 1. Changes in inflation rate



Source: Econstats™.

4. Methodology

As mentioned above, our methodology consists on combining Component GARCH model with threshold order that takes into account transitory and permanent effects and structural breaks in the process of volatility with Morlet transform framework and nonlinear causality test.

4.1. Modeling inflation uncertainty

Autoregressive Conditional Heteroscedasticity type modeling is the predominant technique used in volatility analysis. Hence, to determine inflation uncertainty, we choose to carry out Component GARCH with threshold order. The choice of this specification is attributable to two main reasons:

Firstly, volatile supply leads to temporal changes in demand conditions and thereby to multiple commodity price regime. This creates a need to use a Threshold-GARCH model that detects the responses of inflation after shocks.

$$\sigma_t = \omega + \sum_{i=1}^{q} \alpha_i |\varepsilon_{t-i}| I |\varepsilon_{t\_i} \geq \gamma_i|) + \delta \sum_{i=1}^{q} |\varepsilon_{t-i}| I(\varepsilon_{t-i} \prec \gamma_i) + \beta_j \sigma_{t-i} \quad , \qquad (1)$$

where σ_t: conditional standard deviation, ω: reaction of shock, α: ARCH term, β: GARCH term, ε : error term; I_t: the information set available at time, γ : the leverage effect.

Secondly, the relationship between contemporaneous inflation and its lagged values creates a need to account both short run or long run dynamics by using Component-GARCH model able to decompose the conditional variance into a long-run time-varying trend component and a short-run transitory component (deviations from that trend).

$$(\sigma_t^2 - \sigma^2) = \alpha(\varepsilon_{t-1}^2 - \sigma^2) + \beta(\sigma_{t-1}^2 - \sigma^2) \ ; \ \sigma^2 = \omega/(1-\alpha-\beta) \qquad (2)$$

where $\sigma_t{}^2$: conditional variance.

The component GARCH model with threshold order[3] used in this study to determine inflation uncertainty is the combination between equations (1) and (2).

[3] For more details, we can refer to Bauwens and Storti (2008) and Bouoiyour and Selmi (2013 a).

4.2. Morlet wavelet decomposition

Wavelet analysis is a topic of pure mathematics but in the last years, it seems worth notable the great applicability of wavelet decomposition in many fields (i.e. to assess the nexus between oil price uncertainty and that of real effective exchange rate such as Tiwari Kumar (2013) and to investigate the effect of real exchange volatility on exports performance as Bouoiyour and Selmi (2013 a), etc…). Wavelets are functions that satisfy certain requirements; For example, these latter should integrate to zero and wave above and below x-axis. Alternatively, with this method, the considered function will be well localized. Like sines and cosines in Fourier transform analysis, wavelets are used as basic functions at high frequency called mother wavelet ψ and at low frequency called father wavelet ϕ , which are expressed respectively as follows:

$$\int \psi(t)dt = 0 \quad (3)$$

$$\int \phi(t)dt = 1 \quad (4)$$

A wavelet decomposition of a function $f(t)$ can be defined as a sequence of projections into father and mother wavelets

$$f(t) = \sum_k s_{J,k}\phi_{J,k}(t) + \sum_k d_{J,k}\psi_{J,k}(t) + \sum_k d_{J-1,k}\psi_{J-1,k}(t) + ... + \sum_k d_{1,k}\psi_{1,k}(t) \quad (5)$$

where $s_{J,k}$ is the smooth behaviour of the signal at a specific time scale ; The coefficients $d_{j,k}$ represent deviations from the trend ; J is the number of multi-resolution levels.

The equation (5) highlights the characteristics of wavelets comparable to Fourier transformation. The latter produces changes everywhere in the time domain. Wavelet extraction extends it in terms of localization, i.e. wavelets are well localized in both frequency band via dilations and in time scale via translations. This hints at how extend economists can benefit from this technique. Noisy data can be easily transformed by the discrete wavelet transform.

In this study, we choose a Morlet transform among different wavelet families such as Haar, Symmlet, Mexican hat, Daubechies. The choice of the best function depends on the particularity of considered application (Aguiar-Conraria and Soares, 2011). As the Symmlet wavelets[4] widely used in empirical economic studies, the Morlet is also a succesion of low-pass and high-pass filters to the series in question. However, it is based on the Heisenberg's principle that suppose that the mother wavelet ψ is localized around the point (μ_t, μ_f) of the time frequency plane with uncertainty's degree is given by $\sigma_t\sigma_f \geq 1/4\pi$. μ_f and σ_f represent respectively the center and the variance of the Fourtier transform of the mother wavelet. For Morlet wavelet, the interval [μ_t- σ_t, μ_f -σ_f] is the set where attains its most significant values while the interval [μ_f -σ_f , μ_f +σ_f] represents the minimum requirements imposed on the mother wavelet. The μ_t , σ_t μ_f and σ_f can be expressed respectively as follows:

$$\mu_t = \int_{-\infty}^{+\infty} t|\psi(t)|^2 dt \tag{6}$$

$$\sigma_t = \int_{-\infty}^{+\infty} (t-\mu_t)^2 |\psi(t)|^2 dt \tag{7}$$

$$\mu_f = \int_{-\infty}^{+\infty} f|\psi_f(f)|^2 df \tag{8}$$

$$\sigma_f = \int_{-\infty}^{+\infty} (f-\mu_f)^2 |\psi_f(f)|^2 df \tag{9}$$

4.3. Nonlinear causality test

Several approaches have been developed to address the linearity assumption in Granger causality (Granger, 1969). Accordingly, Granger (1995) shows that the linear causality can vary across frequencies or under various periodicities. More recently, various researches use non-parametric models with Fourier or wavelet transformation. It has been observed that the results of linear Granger causality test significantly change with different scales transformations (Crowsley, 2007). For our case of study, in order to test for nonlinear Granger causality, we use a nonparametric statistical methods proposed by Péguin-Feissolle and Teräsvirta (1999), which are respectively the Taylor series approximation and the artificial neural networks. The Taylor approximation is based on the nonlinear function y_t expressed as follows:

$$y_t = f^*(y_{t-1},\ldots,y_{t-q},x_{t-1},\ldots,x_{t-n},\theta^*) + \varepsilon_t \tag{10}$$

---

[4] For detailed analysis about wavelet decomposition, we can refer to Bouoiyour and Selmi (2013 a).

where θ^* is a parameter vector and $\varepsilon_t \sim nid(0,\sigma^2)$; the sequences x_t and x_t are weakly stationary. The functional form of f^* is unknown but we assume that is adequately represents the causal relationship between x_t and y_t. While trying to test noncausality hypothesis, we start by the fact that x_t does not cause y_t if the past values of x_t does not contain any information about y_t that is already contained in the past values of y_t itself. More precisely, under the noncausality hypothesis, we have:

$$y_t = f\left(y_{t-1},\ldots,y_{t-q},\theta\right)+\varepsilon_t. \tag{11}$$

To test (11) against (10), following Péguin-Feissolle and Teräsvirta (1999), we linearize f^* in (10) by expanding the function into a k-order Taylor series around an arbitrary fixed point in the sample space. We obtain therefore:

$$\begin{aligned} y_t =& \beta_0 + \sum_{j=1}^{q}\beta_j y_{t-j} + \sum_{j=1}^{n}\gamma_j x_{t-j} + \sum_{j_1=1}^{q}\sum_{j_2=j_1}^{q}\beta_{j_1 j_2} y_{t-j_1} y_{t-j_2} + \sum_{j_1=1}^{q}\sum_{j_2=1}^{n}\delta_{j_1 j_2} y_{t-j_1} x_{t-j_2} \\ &+ \sum_{j_1=1}^{n}\sum_{j_2=j_1}^{n}\gamma_{j_1 j_2} x_{t-j_1} x_{t-j_2} + \ldots + \sum_{j_1=1}^{q}\sum_{j_2=j_1}^{q}\cdots\sum_{j_k=j_k-1}^{q}\beta_{j_1\ldots j_k} y_{t-j_1}\ldots y_{t-j_k} \\ &+ \ldots + \sum_{j_1=1}^{n}\sum_{j_2=j_1}^{n}\cdots\sum_{j_k=j_k-1}^{n}\gamma_{j_1\ldots j_k} x_{t-j_1}\ldots x_{t-j_k} + \varepsilon_t^* \end{aligned} \tag{12}$$

According to Péguin-Feissolle and Teräsvirta (1999), there are two difficulties in this last equation. Firstly , the regressors tend to be highly collinear. Secondly, the number of regressors increases rapidly with k, whereas the number of degrees of freedom may become small. To avoid this problem, they replace the regressors in equation (12) by the first p^* principal components of each matrix of observations.

5. Empirical evidence

5.1. Preliminary analysis

In this work, we use monthly data set of consumer price index (source: Econstats and International Monetary Fund) from 1987:M7 to 2009:M10. The descriptive statistics are reported in Table 2. The sample means of inflation returns is positive. The skewness indicates a negative value, implying that inflation returns are skewed relative to a normal distribution. The Jarque–Bera test indicates a high level, meaning a reject of normality of these variables.

Table 2. Descriptive statistics of inflation rate

Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
4.377741	4.425683	4.784153	3.825811	0.251003	-0.450748	2.236763	15.58002

5.2. Main findings

5.2.1. Inflation uncertainty and its persistence

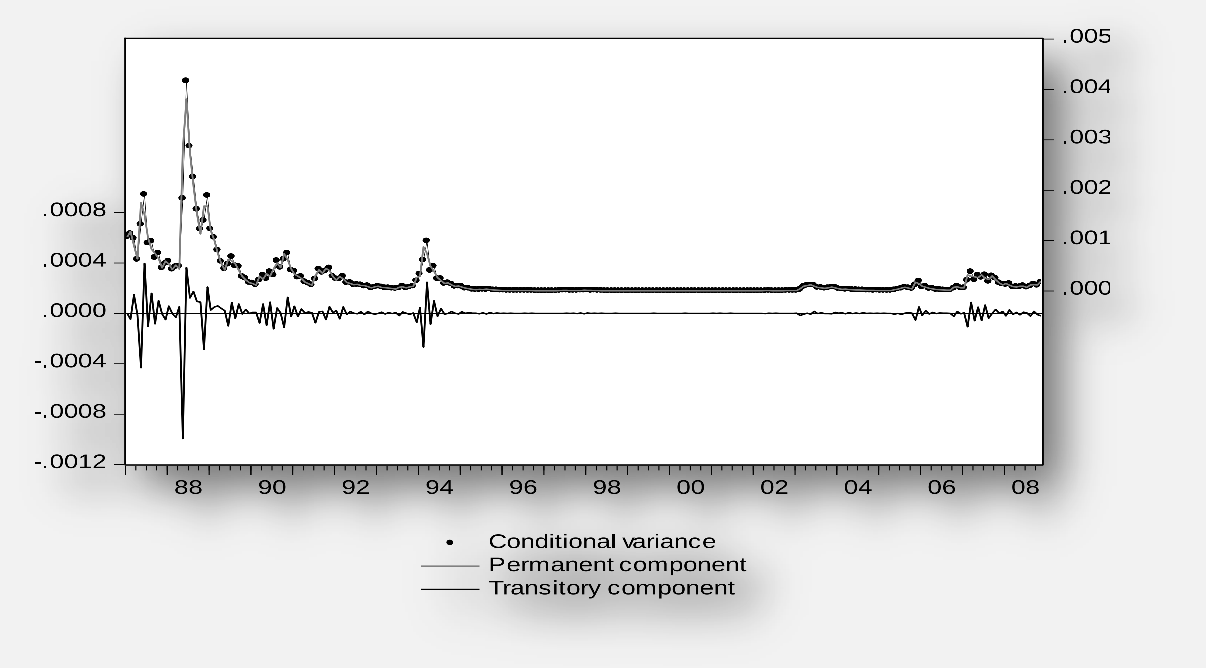
Our main results are reported in Table 3 reveal that the GARCH term (β) is stronger than the ARCH term (α), indicating a long lasting persistence of conditional variance. The duration of persistence ($\alpha + \beta + 0{,}5\gamma$) which is equal to 0.67, indicates that the Egyptian inflation uncertainty is far from a long memory process. The leverage effect (γ) is negative and significant, implying that the Egyptian inflation reacts more to good news than bad news. Hence, we notice that the effect of positive shock on conditional variance ($\alpha + \gamma$) is more intense than that of a negative shock ($-\alpha + \gamma$) equal respectively to 0.39 and -0.20.

Table 3. Conditional variance of inflation rate

	Coefficients	Std. Error	z-Statistic	Prob.
w	1.29E-05	9.77E-07	13.23748	0.0000
α_1	0.213619	1.267003	3.405381	0.0852
α_2	-0.105611	0.764855	-0.138080	0.8902
β_1	0.586977	0.818838	0.228344	0.8194
β_2	0.016383	0.164109	6.099829	0.0205
γ	-0.095714	0.138815	-2.689509	0.0905
R-squared	0.999788	Mean dependent var	4.377741	

Arguably, we observe in Figure 2 the excessive volatile behavior of Egyptian inflation rate when considering the leverage and the threshold effects especially after the second oil shock, which implies the great sensitivity of inflation to the ups and down oil price fluctuations. We notice also that both transitory and permanent effects co-move positively with inflation but the impact of permanent shocks on inflation variance appear stronger. Accordingly, Bhar and Hamori (2004) find that if there is a significant link between inflation rate and the standard deviation of permanent shock, this indicates a strong relationship between inflation and its uncertainty in the long-run. However, if inflation is more correlated to the standard deviation of transitory shock, this implies a heavily important association between the two key variables.

Figure 2. Inflation uncertainty using Component GARCH model



5.2.2. The nexus inflation-inflation uncertainty

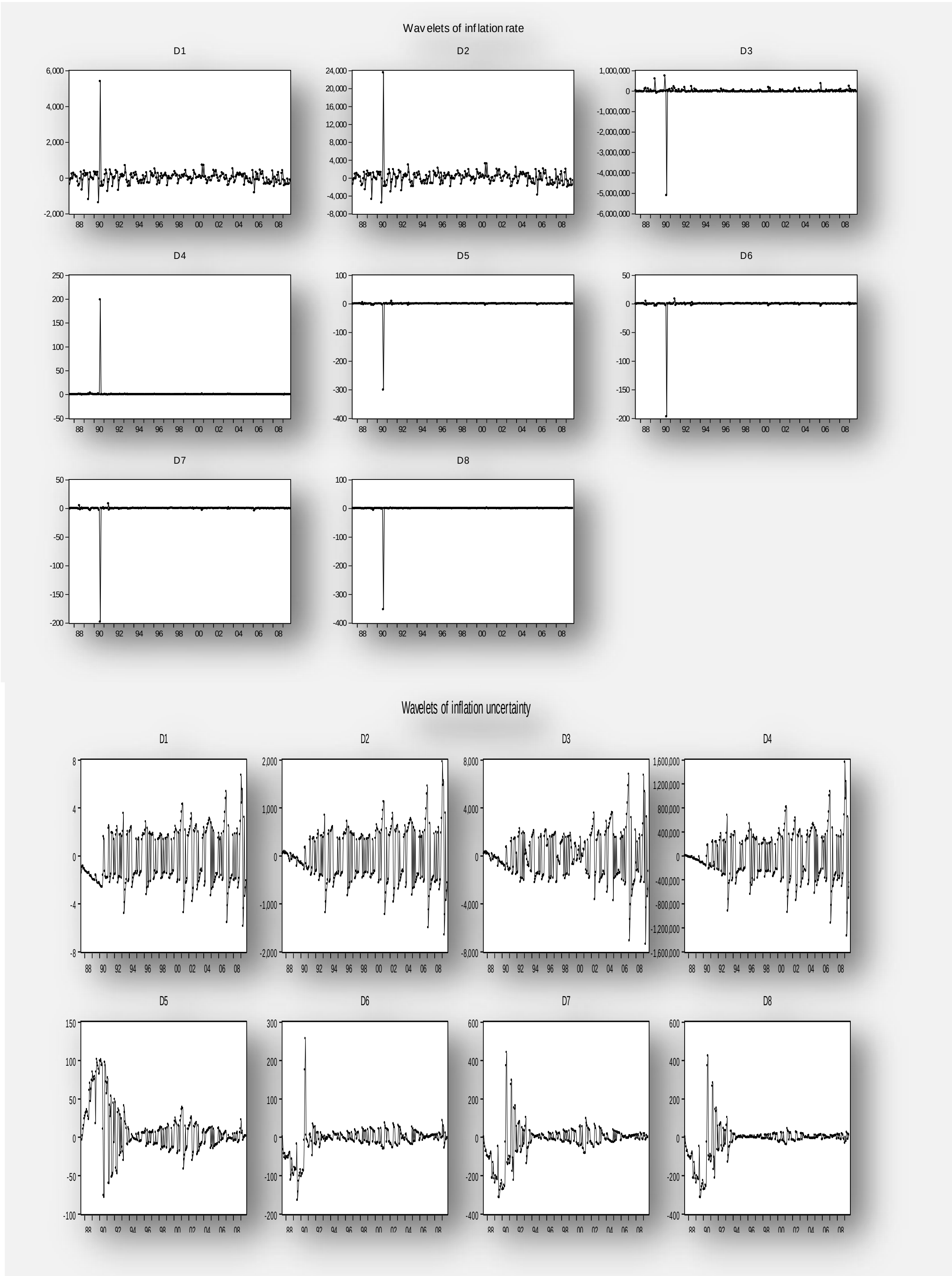
In our knowledge, there are no studies that explore wavelet or Morlet decomposition to decompose inflation and inflation uncertainty to investigate the linkage between the two variables depending to frequency-frequency variation. For our analysis, to assess whether the focal relationship varies over time, we distinguish between time domain and the different frequency bands. The considered time scales are reported in Table 4.

Table 4. Frequency scale bands

Scales	Monthly frequencies
D1	2-4
D2	4-8
D3	8-16
D4	16-32
D5	32-64
D6	64-128
D7	128-256
D8	>256

Figure 3 presents the evolution of inflation and its uncertainty depending to different time scales. We observe clearly that inflation rate fluctuates more at low frequency band than at high frequency. Additionally, it is worth observable that rather than inflation its uncertainty varies also when we moves from low time scale to high time scale. Similarly, we note that inflation uncertainty is more persistent at low frequency band than high frequency band.

Figure 3. Morlet wavelet decomposition of inflation and its uncertainty



In addition, a nonlinear causality test approximated by Taylor (i.e. additive) was applied at different time scales to verify the above findings reported in Figure 4. As depicted in Table 5, we find a nonlinear positive unidirectional link running from inflation to inflation uncertainty, i.e. considering nonlinearities, the Friedman-Ball hypothesis is supported at all time scales. This apparent finding can be attributable as argued by Harmann et al. (2012) to the degree of central bank independence. More specifically, in low CBI economies as our case of study (Bouoiyour and Selmi, 2013 b), the actions of policymakers can engender an instable macroeconomic environment which in turn can create a controversial linkage between inflation and its uncertainty. Nonetheless, the adoption of inflation targeting since 2005 may tend to lower both inflation and its volatility, implying a clearer long-run causal relation supporting the Friedman-Ball hypothesis.

Table 5. Nonlinear causality test (Taylor approximation)

Time domain	Frequency bands (months)							
All Returns	**D1 2-4M**	**D2 4-8M**	**D3 8-16M**	**D4 16-32M**	**D5 32-64M**	**D6 64-128M**	**D7 128-256M**	**D8 >256M**
H_0 :*INF* does not cause *VOLINF*								
0.2873 (0.290)	0.4721 (0.658)	0.4706 (0.500)	0.2341 (0.239)	0.6821 (0.326)	0.6809 (0.501)	0.5517 (0.386)	0.7211 (0.404)	0.7926 (0.382)
H_0 : *VOLINF* does not cause *INF*								
0.0891 (0.041)	0.0635 (0.037)	0.0651 (0.009)	0.0439 (0.026)	0.0672 (0.045)	0.0691 (0.082)	0.0596 (0.088)	0.0679 (0.069)	0.0683 (0.059)

Note : (.) : the p-value.

Taken together time domain, low and high frequencies results, we show a strong support for an undirectional link that runs from inflation level to its uncertainty in all scales. Friedman (1977) and Ball (1992) associate the significant effect of inflation on inflation uncertainty to the increasing unemployment level as well as the political unrest leading the society to be polarized. In this situation, public does not know the tastes of future policymakers and whether disinflation will occur. This policy uncertainty about the future inflation rates is one of the main drivers of uncertainty about inflation. More precisely, the uncertainties about when and how policy authorities decide to intervene for price stability purposes, the stronger will be the inflation volatility. We can also add the period of high inflation after the second oil shock and also since 2001 after september'events (see Figure 1), which destabilizes the relation between the money stock and monetary institutions and increases then monetary control errors.

However, the nonlinear relationship appears stronger at high frequency band. We associate this finding the permanent effects that co-move intensely and positively with inflation (see Figure 2). This high correlation between permanent shock and inflation conditional variance can lead to a long-run relationship between inflation and its volatility (Bhar and Hamori, 2004). Moreover, a strong association between inflation and inflation uncertainty at high scale may be due to the incidence of exogenous shocks (i.e. For example between the rise of oil prices after 2001 events and the decrease of central bank independence in 2003). In that context, Evans (1991) shows that the correlation between increases in the persistence of inflation and an oil shock period yields to a great interaction between the inflation and its volatility. Importantly, the starting of inflation targeting implementation since 2005 (Kandil and Dincer, 2008) may tend to lower inflation and then its volatility, implying a clearer long-run causal relation supporting the Friedman-Ball hypothesis.

Furthermore, the apparently mixed results in terms of the coefficients'intensity from one frequency to another may be attributable to the asymmetry between inflation booms and recessions and the downward expectations of monetary authorities (Ball, 1992).

5.2.3. Some economic implications

The above finding about the positive association between inflation rate and its uncertainty and the evidence in favor of Friedman Friedman-Ball hypothesis create a need to minimize the effect of inflation rate on its uncertainty in Egyptian case. This means that uncertainty arises about the timing of monetary policy actions to reduce inflation, especially because the effects of policy take time to occur (Holland, 1993). Indeed, the complexity in predicting how strongly and how quickly prices will respond to monetary policy increases inflation uncertainty. In addition, the step taken toward decreased central bank independence of Egypt in 2003 (Bouoiyour and Selmi, 2013 b) and the rapid increase in domestic credits during this period lowered the effectiveness of the stabilization policy. Alternatively, in low CBI economies as Egypt, the actions of policymakers can engender an instable macroeconomic environment which in turn can create a controversial linkage between inflation and its uncertainty (Hermann et al. 2012).

Our results appear interesting and have a clear economic implication : Central Bank of Egypt should continue to work toward price stability to mitigate the disruption in policy decisions and the welfare costs of inflation and its uncertainty. To achieve this goal, it seems highly important to enhance the transparency and accountability of Central Bank of Egypt by improving the quality of information regarding lagged, current and predicted values of inflation. Moreover, the coordination between monetary policy and fiscal policy can help Egyptian authorties to react quickly and effectively to shocks. Specifically, a flexible fiscal policy can mitigate the transmission-damaging from inflation to inflation uncertainty.

6. Conclusion

We revisit the nexus between inflation and inflation uncertainty in order to point a robust relationship between the two variables. To do so, our article takes another look at the evidence by decomposing inflation and its uncertainty to various scales based on Morlet transform.

Our results support Friedman-Ball hypothesis by showing a positive association that runs from inflation to inflation uncertainty at time domain (i.e. all returns) and all considered time scales. Interestingly, it appears that the intensity of this link depends to frequency-to-frequency variation, i.e. inflation affects more uncertainty about inflation at high frequency bands than that at low frequencies. We mainly attribute these findings to the the permanent shocks that undergine Egypt in this period, the asymmetry between inflation booms and recessions, the downward expectations of monetary authorities and the complexity in predicting the timing at which prices will respond to monetary policy.

In nutshell, the conclusion that high inflation is significantly associated to high unceratinty is even more compelling. Our study reaffirms the significant unidirectionnal link that runs from inflation to inflation uncertainty and reconcile the inconclusive results in previous work. This study offers also a clear implication, the Central Bank of Egypt should continue to work toward price stability. This seems a hard enough, especially with the political instability in the aftermath of revolution but our result can elucidate the understanding of Egyptian policymakers, advisors and practitionners and help them to mitigate the disruption of decision-making.

References

Achour, M. and Trabelsi, A. (2011) : Markov Switching and State-Space Approaches for Investigating the Link between Egyptian Inflation Level and Uncertainty. Review of Middle East Economics and Finance, 6 (3), pp. 46-62.

Aguiar-Conraria, L. and Soares, M. J. (2011) : Business Cycle Synchronization and the Euro: a Wavelet Analysis. Journal of Macroeconomics, 33(3), pp. 477 - 489.

Baek, E. and Brock, W. A., (1992): General Test for Nonlinear Granger Causality: Bivariate Model. Working Paper of University of Wisconsin-Madison.

Baillie, R., Chung, C. and Tieslau, M. (1996): Analyzing inflation by the fractionally integrated ARFIMA-GARCH model‘, Journal of Applied Econometrics, Vol. 11, pp. 23–40.

Ball, L., (1992) : Why does higher inflation raise inflation uncertainty? Journal of Monetary Economics, Vol. 29 (3), 371–378.

Bauwens, L. and Storti, G. (2008): A component GARCH model with time varying weights. Manuscript 1512 Studies in nonlinear dynamics and econometrics.

Bhar R and Hamori S (2004): The Link between Inflation and Inflation Uncertainty: Evidence from G7 Countries. Empirical Economics, 29, 825-853.

Benhmad, F. (2012) : Modeling nonlinear Granger causality between the oil price and US dollar: A wavelet approach. Economic modeling 29, pp. 1505-1514.

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

Bouoiyour, J. and Selmi, R. (2013 a): Exchange Volatility and Export Performance in Egypt: New Insights from Wavelet Decomposition and Optimal GARCH Model. Working paper CATT, University of Pau.

Bouoiyour, J. and Selmi, R. (2013 b) : The effects of central banks' independence on inflation outcomes in emerging countries: Does the choice of exchange regime matter? Chapter 9 in the Book "Exchange Rates in Developed and Emerging Markets: Practices, Challenges and Economic Implications", edited by Mohsen Bahmani-Oskooee.

Brunner, A. D., and Hess, G. D. (1993): Are higher levels of inflation less predictable? A state-dependent conditional heteroskedasticity approach. Journal of Business and Economic Statistics, 11, 187–197.

Cukierman, A. and A. Meltzer (1986) : A theory of ambiguity, credibility and inflation under discretion and asymmetric information. Econometrica, 54, pp. 1099- 1128.

Cukierman A (1992) : Central Bank Strategy and Independence: Theory and Evidence. Cambridge MA: MIT Press.

Crowley, P., (2007) : A guide to wavelets for economists. Journal of Economic Surveys, 21 (2), pp. 207–267.

Devereux, M. (1989): A positive theory of inflation and inflation variance, Economic Inquiry, 27, pp. 105-16.

Elder J., (2004) : Another Perspective on the Effects of Inflation Uncertainty. Journal of Money, Credit and Banking, 36, pp. 911-928

Fountas, S. (2001): The relationship between inflation and inflation uncertainty in the UK: 1885-1998, Economics Letters, 74, pp. 77-83.

Friedman, M. (1977): Nobel lecture: inflation and unemployment, Journal of Political Economy, 85, pp. 451-72.

Granger, C.W.J., (1969) : Investigating causal relation by econometric and cross-sectional method. Econometrica, 37, pp. 424–438.

Granger, C.W.J., Lin, J.L. (1995) : Causality in the long run. Econometric Theory, 11, pp. 530–536.

Grier, K., and Perry, M. (1998): On inflation and inflation uncertainty in the G7 countries. Journal of International Money and Finance, 17, pp. 671–689.

Grier, K., Henry, O. T., and Shields, K. (2004): The asymmetric effects of uncertainty on inflation and output growth. Journal of Applied Econometrics, 19, pp. 551-565.

Hachicha, A. and Lean, H-H. (2013) : Inflation, Inflation Uncertainty and Output in Tunisia. Economics Discussion Papers, N° 2013-1, Kiel Institute for the World Economy.

Hartmann, M. and Herwartz, M. (2012) : Causal relations between inflation and inflation uncertainty- Cross sectional evidence in favour of the Friedman-Ball hypothesis. Economics Letters, 115, pp. 144-147.

Hermann, S-A., Chanana, C. and Serapio, B. (2012) : Uncertainty of inflation and inflation rate: Does credibility of inflation policy matter ? Economic issues, 17 (2), pp. 95-110.

Holland, S. A. (1993) : Comments on inflation regimes and the sources of inflation uncertainty, Journal of Money, Credit, and Banking, 25, pp. 514–520.

Karanasos Menelaos and Stefanie Schurer (2008): Is the Relationship between Inflation and Its Uncertainty Linear? German Economic Review 9(3), pp. 265–286

Karanasos, M., Karanassou, M. and Fountas, S. (2004): Analyzing US inflation by a GARCH model with simultaneous feedback. WSEAS Transactions on Information Science and Applications, 1, pp. 767 772.

Kontonikas, A., (2004) : Inflation and inflation uncertainty in the United Kingdom, evidence from GARCH modelling. Economic Modelling, Vol. 21 (3), 525–543.

Nas T and Perry M (2000) : Inflation, Inflation Uncertainty and Monetary Policy in Turkey: 1960 – 1998. Contemporary Economic Policy, 18, pp. 170- 180.

Neyapti B (2004). Fiscal decentralization, central bank independence and inflation: a panel investigation. Economics Letters, 82(2), pp. 227-230.

Okun A (1971) : The Mirage of Steady Inflation. Brookings Papers on Economic Activity, 1971, pp. 485-498.

Pedroni P (2001) : Purchasing Power Parity in Cointegrated Panels. The Review of Economics and Statistics, 83(4), pp. 727-731.

Pourgerami, A. and Maskus, K. (1987) : The effects of inflation on the predictability of price changes in Latin America: some estimates and policy implications". World Development, 15 (2), pp. 287–290.

Ungar, M., and B. Zilberfarb, (1993) : Inflation and its unpredictability, theory and empirical evidence. Journal of Money, Credit, and Banking, 25 (4), pp. 709–720.

Zakoian, J.M. (1994) : Threshold Heteroskedastic Models. Journal of Economic Dynamics and Control, 18, pp. 931-55.

Zeynel, A., zdemir, O. and Mahir, F-L. (2008): On the inflation-uncertainty hypothesis in Jordan, Philippines and Turkey: A long memory approach. International Review of Economics and Finance 17, pp. 1-12.