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**THE NEXUS  
BETWEEN INFLATION AND  
INFLATION UNCERTAINTY  
VIA WAVELET APPROACH:  
SOME LESSONS  
FROM EGYPTIAN CASE**

**Jamal BOUOYOUR  
Refk SELMI**

**CATT-UPPA**  
UFR Droit, Economie et Gestion  
Avenue du Doyen Poplawski - BP 1633  
64016 PAU Cedex  
Tél. (33) 5 59 40 80 01  
Internet : <http://catt.univ-pau.fr/live/>



# The Nexus between Inflation and Inflation Uncertainty via Wavelet Approach: Some Lessons from Egyptian Case

Jamal BOUOYOUR

CATT, University of Pau, France.

E-mail : [jamal.bouoyour@univ-pau.fr](mailto:jamal.bouoyour@univ-pau.fr)

Refk SELMI

ESC, Tunis Business School, Tunisia.

E-mail : [s.refk@yahoo.fr](mailto:s.refk@yahoo.fr)

**Abstract:** The nexus between inflation and its uncertainty has been a topic of wide dispute. Using wavelet decomposition and with special reference to Egypt for the period 1960:M06-2013:M12, we find that the focal relationship varies substantially among the different frequencies involved. In the short-run, inflation expands inflation uncertainty and vice versa. In the medium term, higher inflation leads to greater volatility, while there is no evidence of significant link in the long-run. The main causes of these mixed outcomes have been organized into demand pull factors, cost push ones and the possible reflect of the conflicting underlying objectives pursued to avoid political pitfalls and the great instability that unfolded since 25<sup>th</sup> January 2011.

**Keywords:** Inflation; inflation uncertainty; wavelet approach; Egypt.

## 1. Introduction

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. As inflation rates have continued to fall in world-wide, several researches have focused on the problems associated with high levels of inflation. Up to now, the inflation costs and the challenges ahead have been the topics of considerable dispute.

An area of contention of the relationship between inflation and inflation uncertainty is the direction of connection. One side of the debate is associated with Friedman (1977) and Ball (1992), showed that a rise in the average rate of inflation leads to more uncertainty about the future inflation rate. Other group including essentially Cukierman and Meltzer (1986) supported the opposite direction of causation. Pourgerami and Maskus (1987) offer different evidence. They show that, in the presence of rising inflation, agents may invest more resources in forecasting inflation, reducing then inflation uncertainty. The great resurgence of interest in the focal field and the difficulty to reach a solid and clearer nexus creates a need to re-analyze this link while trying to find better paths.

Recently, various researches on different topics have recognized that there are different time periods for decisions-making, whereas assessments are usually restricted to time domain or at least two time horizons, namely, the short-run and the long-run. Very few works have paid attention to how inflation evolves over time using wavelet decomposition (Ysusi, 2009). Because inflation dynamic may change due to external shocks and domestic pressures, time frequency analysis allows us to estimate the long-term trend, cyclicity, seasonality without neglecting local shocks of inflation series.

Intuitively, an Analysis of inflation development with special reference to Egypt and using wavelet approach may be interesting for at least two main reasons. First, monetary authorities have different objectives determined stochastically over time that lead to evaluate frequently the interaction dynamic between the concerned

macroeconomic time series. Second, the monetary policy has remarkably witnessed great improvements from 1960 to 2013. In the short-run, the focal economy suffered from macro imbalances, heavily reflected in the volatile trend of inflation. In the medium term, inflation evolution was subject to sizable fluctuations mainly owing to successive exchange rate devaluation from 2000. In the long-run, due to the political event that unfolded in Egypt since the end of January 2011, inflation displayed an extra volatility. This can be attributed to several conflicting aims pursued by Egyptian monetary authorities to mitigate the possible damageable economic repercussions (the confidence in Egyptian economy dropped sharply, the economic growth decreased heavily, the monetary situation deteriorated considerably and public finance came under severe pressure).

Our principal objective here is to test whether there is a causal link between inflation and inflation uncertainty at distinct frequencies. While trying to effectively tackle the potential factors behind the debate controversy, we assess the focal link at well defined time horizons (i.e. from lower to higher frequencies). To do so, a nonlinear causality test within a wavelet transform framework<sup>1</sup> has been carried out. Additionally, instead of standard deviation of inflation, an appropriate GARCH model chosen among various GARCH extensions is used as measure of inflation uncertainty.

The remainder of the article proceeds as follows: Section 2 presents a brief overview of monetary policy development in Egypt for a large period that spans between 1960 and 2013. Section 3 describes data and presents the followed methodology. Section 4 reports the main obtained findings and discusses them. Section 5 deals with conclusions and economic implications.

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<sup>1</sup> This methodology has been followed by several researches on other controversial topics including the nexus between oil price and real exchange rate (Benhmad (2012) and Bouoiyour and Selmi (2014)) and consumer price and producer price (Tiwari et al. 2014). The combination between causality test and wavelet decomposition while accounting for nonlinearity have helped to obtain conclusive results.

## 2. Brief overview of monetary policy developments

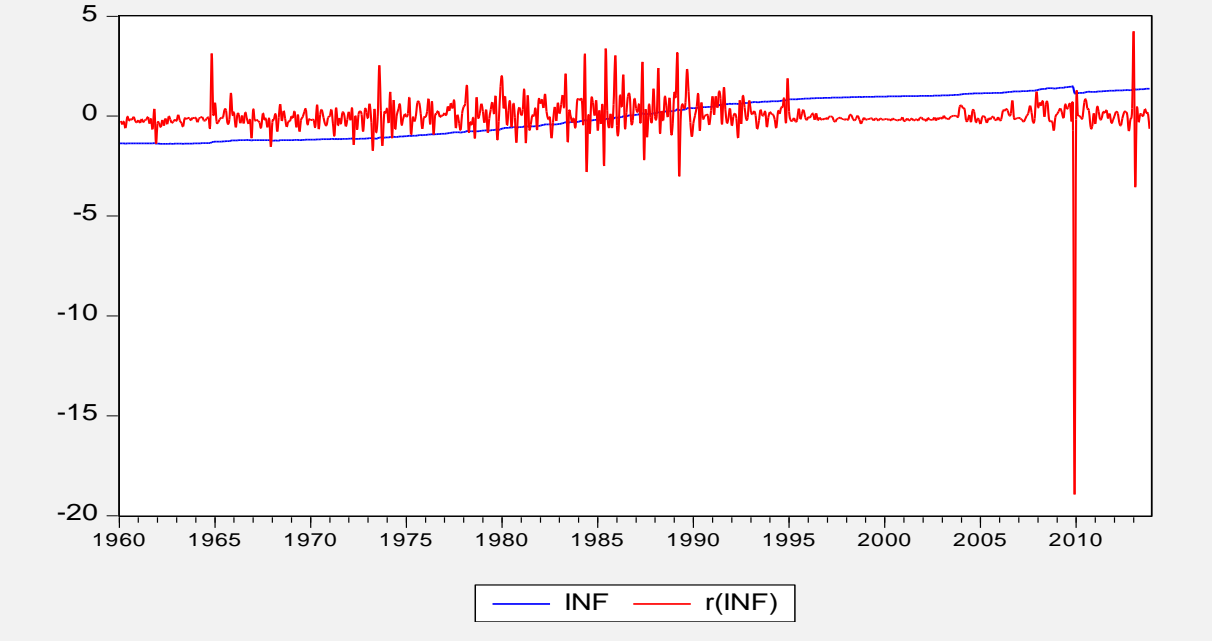
During the 1970s, Egypt suffered from macro imbalances. This unpleasantly reflects the volatile behavior of inflation, increasing intensely deficits in the balance of payments. Following the oil shock of 1985-1986, the fiscal deficit was accommodated through expansionary monetary policy leading to a great increase in inflation rate. 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 events 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 (Kandil and Nergiz, 2008). 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, putting government under pressure. This has created a need to follow a policy of price stabilization since 1991 by implementing a structural adjustment program. From 2002, inflation development in Egypt varied widely due to successive depreciation in the domestic currency. Since 2004, the Central Bank of Egypt took proactive and drastic reforms in order to enhance its monetary and fiscal policies to facilitate the shift to an inflation targeting regime. . This declaration raises a fear about its successfulness (if this economy is really able to conduct this new regime that needs various institutional and economic reforms to ensure properly and effectively the inflation targeting prerequisites). As response, various measures have been achieved including the launch of the comprehensive banking sector program (in particular, the privatization of banks and the liberalization of foreign exchange markets) and the starting of the banking law n° 88 of 2003 (the improvement of the Central Bank independence, Bouoiyour and Selmi (2013)). Nevertheless, the great deterioration in external environment and the aftermath of economic crisis in Europe (the major trading partner of Egypt<sup>2</sup>) in 2008 has threatened the economic situation of Egypt. It has led to a remarkable deficit in

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<sup>2</sup>The main trading partners of Egypt are respectively Italy (8%), USA (7.9%), India (6.4%), Germany (4.7%), Saudi Arabia (4.6%), France (4.5%) and Spain (3.9%). For more details, we can refer to <http://atlas.media.mit.edu/profile/country/>

the balance of payments. More recently, the aftermath of the revolution has altered considerably the macroeconomic performance of Egypt. The economic environment was characterized by a slowdown in economic growth, increasingly trend of inflation and great depreciation of Egyptian pound. Additionally, the notable increase in socially-gearred spending, the public revenues weakness and the increase in debt stock as well as the deterioration of the balance of payment prompt the fiscal position of this country again under great pressure. Figure 1 clearly depicts the above events by showing that inflation surged over time. Therefore, the real reaction of inflation rate on the external events and the actions of policymakers requires a very prime need to be re-investigated. This remains our main aim throughout the rest of this article.

**Figure 1. Changes in inflation rate**



Source: Econstats™. ; INF: Inflation rate in logarithm; r(INF) : Inflation returns.

### 3. Methodological framework

Existing economic literature provides several researches applying various approaches to appropriately investigate the nexus between inflation and inflation uncertainty. Despite the large strand of literature on the issue, it is striking to note

that the previous studies have not paid proper attention to frequency transformations when examining the concerned link. Our methodology consists on: (i) choosing the optimal GARCH model among various GARCH extensions to determine inflation volatility and (ii) assessing the directional causality between considered time series by applying nonlinear causality test among different frequencies through wavelet decomposition.

Obviously, the standard causality and more precisely the conventional econometric techniques suppose that each connection between macroeconomic time series is stable. This assertion is far from reality. The economic environment may undergone tranquil period and turbulent ones (crisis, market tensions, transitional period, political instability, etc...). Thus, the relationship between two macroeconomic variables such as inflation and its volatility is seemingly unstable. This highlights the need to account for nonlinearity as well as frequency transformations. Given these circumstances, the combination between nonlinear causality test and wavelet decomposition may be highly appropriate.

Basically, wavelet method may avoid this gap since it is able to highlight when a variation happens by identifying accurate time horizons. This heavily indicates the great importance of deeper analysis of causal link while accounting for nonlinearity. The followed methodology enables to evaluate effectively the causal interaction between the variables under consideration in defined time scales (i.e. in the short-, medium- and long-run). The obtained outcomes may help considerably policymakers and advisers in their policy formulation and their decisions well-being.

### **3.1.The appropriate model among various GARCH extensions**

While modeling strategies have evolved over time to incorporate new developments in econometric analysis, no single measure of volatility has dominated the literature. Autoregressive Conditional Heteroscedasticity approach is the predominant volatility proxy. Theoretically, the unobserved conditional variance has affected widely the development of various GARCH-type models. Several



specifications have been advanced to capture different features in the process of conditional variance (Engle (1982) and Bollerslev et al. (1993)). In the present research, we carry out 13 GARCH extensions<sup>3</sup> while trying to choose the more proper and appropriate model that can better capture inflation uncertainty. Before choosing this model, we consider an indicator that replaces the changes in inflation at date t in accordance with lagged inflation returns.

$$r_{INF} = \log(INF_t / INF_{t-1}) \quad (1)$$

where  $r_{INF}$  is the return of inflation.

Then, we apply the following model:

$$r_{INF_t} = \alpha + \beta r_{INF_{t-1}} + \varepsilon_t \quad (2)$$

where  $\beta$  is the focal parameter, which can be significant or insignificant depending on whether inflation returns at date t are linked to those at date t-1;  $\varepsilon_t$  is the error term.

To this end, we use standard information criteria based on the historical evaluation such as the Akaike criterion, the Bayesian Criterion and Hannan and Quinn criterion and loss functions based on forecasting performance like Root Mean Square Error (RMSE) and Mean Absolute Error (MAE). Table A.1 (Appendices) reports the main results. We clearly show that the Exponential GARCH proposed by Nelson (1991) is the optimal model. This specification depends not only on the sign of innovation, but also on the power of shock. It is expressed as follows:

$$\log(\sigma_t^2) = \omega + \alpha_1 \left| \frac{\mu_{t-1}}{\sigma_{t-1}} \right| + \gamma \frac{\mu_{t-1}}{\sigma_{t-1}} + \beta_1 \log(\sigma_{t-1}^2) \quad (3)$$

---

<sup>3</sup> We carry out linear vs nonlinear and symmetrical vs asymmetrical GARCH models. We should mention here that the conditional variance may follow two different processes (Zakoin, 1994) depending on the sign of the error terms (nonlinear effect). It depends substantially on the sign of shocks or the asymmetrical effect (Nelson, 1991). However, the linear and symmetrical GARCH extensions are rather restrictive. They consider only the magnitude of shocks (Bollerslev, 1986).

where  $\sigma_t^2$ : conditional variance,  $\omega$ : reaction of shock,  $\alpha_1$ : ARCH term,  $\beta_1$ : GARCH term,  $\mu$ : innovation,  $\gamma$ : leverage effect.

### 3.2. Wavelet decomposition

Wavelet analysis has created recently much excitement in economics and finance. Wavelet transform represents an engineering tool for multi-resolution decomposition of signals that has attracted serious attention by several economists. From a computational point of view, it evaluates the time scale details of data whose content varies over time. This method corresponds to oscillating functions that decay rapidly with time. It exhibits the time contribution of the different frequencies to the signal, to obtain then temporal frequency dependence and scale-by-scale dynamic interactions between the studied variables. Considering lower and higher frequencies, we can differentiate between time horizons for decision making and we can approximate structural changes that can happen over time. Thus, the problem of temporal aggregation bias can be neglected. Wavelet decomposition seems therefore appropriate to depict signal transformations. It precisely indicates how the signal moves among well given frequency bands. This approach is based on the mother wavelet denoted  $\psi(t)$ :

$$\int_{-\infty}^{+\infty} \psi(t) dt = 0, \int_{-\infty}^{+\infty} |\psi|^2 dt = 1 \quad (4)$$

To evaluate the nexus between inflation and inflation uncertainty in different time horizons, the mother wavelet gets deleted. We obtain therefore:

$$\psi_{u,s} = \frac{1}{\sqrt{s}} \psi\left(\frac{t-u}{s}\right) \quad (5)$$

where  $u$  and  $s$  are the time location and frequency ranges, respectively.

Unlike time domain, wavelets can identify which frequencies are present in the data at any given point in time. Ultimately, we obtain the wavelet representation of the function  $Y(t)$ :

$$Y(t) = [w_1(t), v_1(t), \dots, w_j(t), v_j(t)] \quad (6)$$

where  $w_1(t)$  and  $v_1(t)$  are respectively the high frequency and the low ones.

### 3.3. Nonlinear causality test

Several approaches have been developed to address the assumption of linearity of standard Granger causality test. This model is ineffective in detecting possible structural breaks in the causal link between each macroeconomic variables (Chen et al. (2004), Diks and Panchenko (2005), Hiemstra and Jones (1994), Hiemstra and Kramer (1997) and Péguin-Feissolle and Teräsvirta (1999)). Arguably, Granger (1995) advances that the linear causality can vary across frequencies. Thus, it seems substantial to test causality between inflation and its uncertainty at different time-frequencies to gauge properly whether there is a certain level at which the directional causality between the two key variables changes. For this purpose, we carry out a Taylor approximation proposed by Péguin-Feissolle and Teräsvirta (1999). This method is based on the nonlinear function  $y_t$  expressed as follows:

$$y_t = f^*(y_{t-1}, \dots, y_{t-q}, x_{t-1}, \dots, x_{t-n}, \theta^*) + \varepsilon_t \quad (7)$$

where  $\theta^*$  is a parameter vector and  $\varepsilon_t \sim nid(0, \sigma^2)$ ; the sequences  $x_t$  and  $y_t$  are weakly stationary. The functional form of  $f^*$  is unknown but we assume that it adequately represents the causal relationship between  $x_t$  and  $y_t$ . To test non-causality 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  $y_t$ , we have therefore:

$$y_t = f(y_{t-1}, \dots, y_{t-q}, \theta) + \varepsilon_t. \quad (8)$$

To test (8) against (7), we linearize  $f^*$  in (7) by expanding the function into a  $k$ -order Taylor series around an arbitrary fixed point in the sample space. We obtain the following equation:

$$\begin{aligned}
y_t = & \beta_0 + \sum_{j=1}^q \beta_j y_{t-j} + \sum_{j=1}^n \gamma_j x_{t-j} + \sum_{j_1=1}^q \sum_{j_2=j_1}^q \beta_{j_1 j_2} y_{t-j_1} y_{t-j_2} + \sum_{j_1=1}^q \sum_{j_2=1}^n \delta_{j_1 j_2} y_{t-j_1} x_{t-j_2} \\
& + \sum_{j_1=1}^n \sum_{j_2=j_1}^n \gamma_{j_1 j_2} x_{t-j_1} x_{t-j_2} + \dots + \sum_{j_1=1}^q \sum_{j_2=j_1}^q \dots \sum_{j_k=j_k-1}^q \beta_{j_1 \dots j_k} y_{t-j_1} \dots y_{t-j_k} \\
& + \dots + \sum_{j_1=1}^n \sum_{j_2=j_1}^n \dots \sum_{j_k=j_k-1}^n y_{j_1 \dots j_k} x_{t-j_1} \dots x_{t-j_k} + \varepsilon_t^*
\end{aligned} \tag{9}$$

## 4. Main findings

### 4.1. Preliminary analysis

For empirical purpose, we have collected monthly frequency data on inflation (INF) over a large period of 1960M2-2013M6. Inflation is proxies by consumer price index and collected from Central Bank of Egypt (CBE). We have converted all series into logarithm to obtain efficient results. The results of descriptive statistics are reported in Table 1. The sample mean of log of inflation is positive. The degree skewness shows a negative value, indicating that inflation is skewed relative to a normal distribution. The Jarque-Bera test reveals a higher value, implying the reject of normality of this variable.

**Table 1. Descriptive statistics of inflation**

Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
2.840077	2.923162	5.108971	0.707543	1.537587	-0.048844	1.372576	71.65661

### 4.2. Inflation uncertainty and its persistence

The appropriate GARCH is the model with the lowest values of information criteria and loss-functions. Table A.1 (Appendices) reports the results revealing that the Exponential GARCH (E-GARCH) is more appropriate than others to measure inflation uncertainty. This highlights the importance of accounting for asymmetry when studying inflation instability, particularly for Egypt. It is well found from the application of E-GARCH that the lagged inflation rate returns ( $r_{INF,t-1}$ ) affects positively and significantly those at date t ( $r_{INF,t}$ ). An increase by 10% in lagged

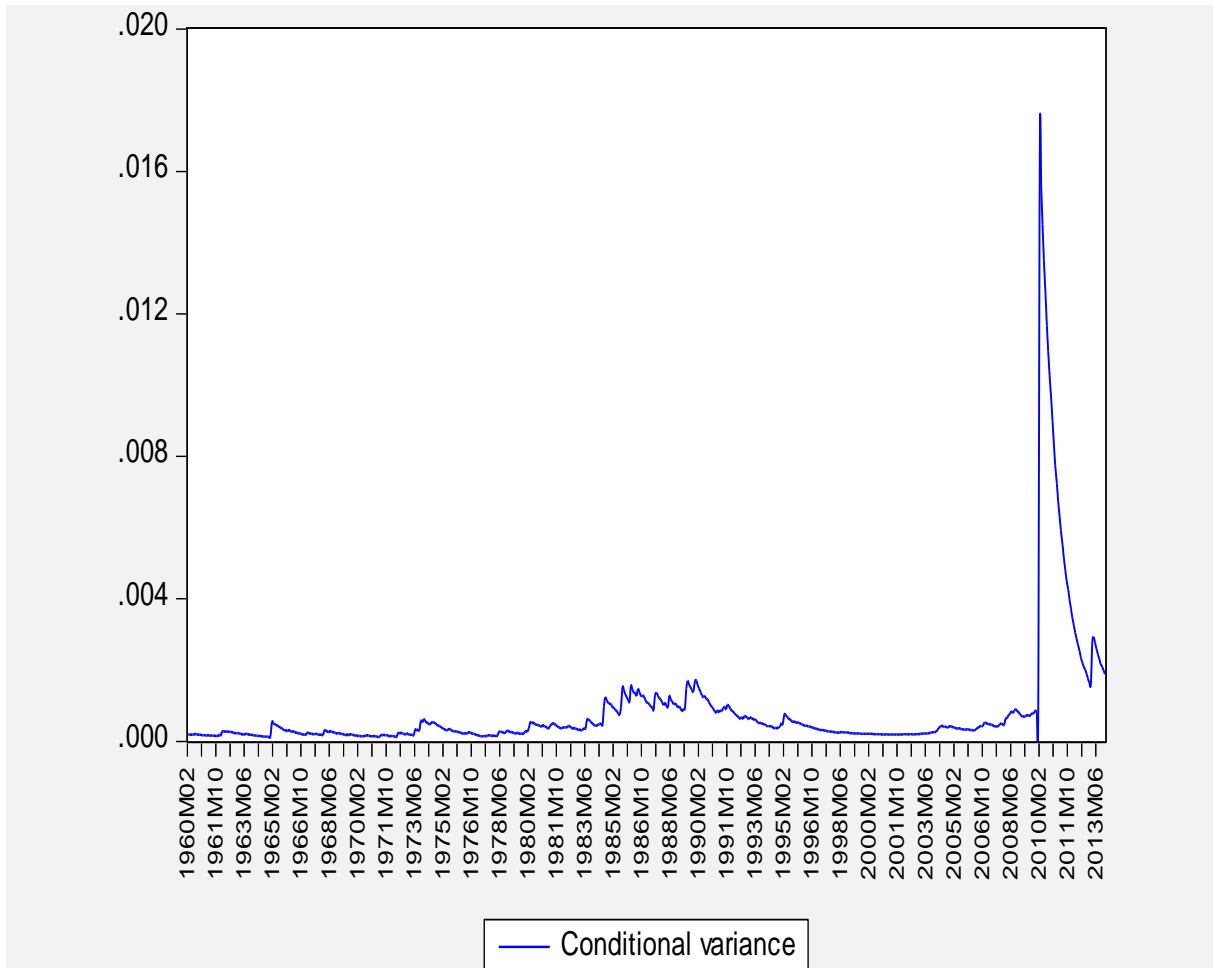
inflation changes lead to a rise in inflation returns at date  $t$  by 0.85% (Table 2). The uncertainty about future inflation seems very persistent and explosive (i.e.  $\alpha + \beta + 0.5\gamma$  amounts 1.10). The leverage effect ( $\gamma$ ) is positive and significant, implying that logarithm of conditional variance reacts more to bad news than good news.

**Table 2. Conditional variance of inflation rate**

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Mean Equation				
$C$	0.002252	0.000139	16.24404	0.0000
$r_{INF_{t-1}}$	0.085508	0.025735	3.322611	0.0009
Variance Equation				
$w$	5.75E-07	6.55E-07	0.878095	0.3799
$\alpha$	0.312952	0.140425	9.349864	0.0000
$\beta$	0.640277	0.252363	26.31242	0.0000
$\gamma$	0.317169	0.016216	19.55923	0.0000

Figure 2 indicates that the inflation fluctuates slightly from 1960 to 1983, becomes sharply greater from 1985 to 1991, and reaches the highest level with the aftermath of the revolution (“the Arab Spring”) particularly in 25<sup>th</sup> January 2011. Unsurprisingly, this last period has undergone deterioration of fiscal position, depreciation of pound, deficit in the balance of payments and unpleasant increase in external debt. Then, we notice that the inflation uncertainty becomes less important. This may reflect the drastic efforts pursued by Egyptian government to attenuate the extra-volatility and thus to overcome its damageable effects on the whole economy.

**Figure 2. Inflation volatility using Exponential GARCH model**



#### **4.3. The frequency-to-frequency direction of causality between inflation and inflation uncertainty**

In our best knowledge, there are no studies that explore wavelet approach in order to analyze the nexus between inflation and inflation uncertainty. We clearly observe the slight movements of inflation rate (graph 1, Figure 3) and its greater volatility (graph 2, Figure 3). Both time series vary over time (i.e., change substantially depending to time-frequency variation). We cannot say at this stage if inflation rate precedes inflation uncertainty or inversely.

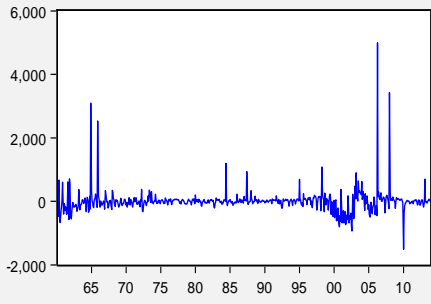
Thus, it will be important in the following to carry out causality test to show the direction of connection between key variables among different frequencies. By doing so, we show a sharp complexity of identifying a clearer nexus between the concerned time series in Egypt. Our main findings can be summarized as follows:

- (i) In the short-run (i.e., higher frequencies including D1:2-4M and D2:4-8M), we support a bidirectional causality.
- (ii) In the medium term (i.e., under D4:16-32M, D5:32-64M and D6:64-128M), it is well revealed that inflation causes inflation uncertainty, while the reverse link is not checked. We support therefore Friedman Ball hypothesis.
- (iii) In the long-run (i.e., lower frequencies including D7:128-256M, D8:256-512M and D9 :> 512M), there is no evidence of causal relationship between inflation and inflation volatility.

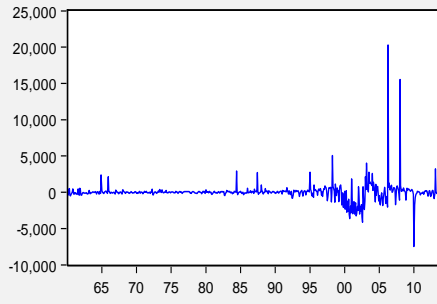
**Figure 3. Wavelet decomposition of inflation rate and its volatility**

INF

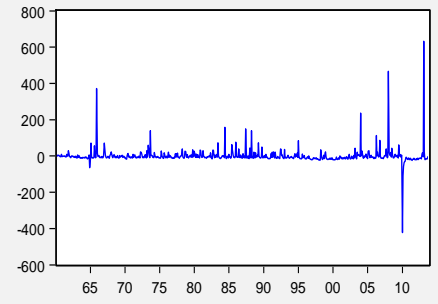
D1: 2-4M



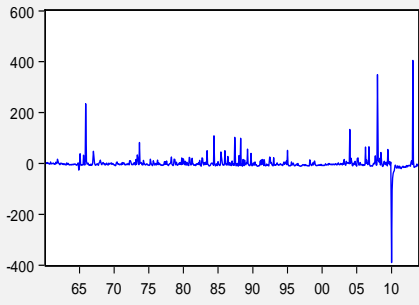
D2: 4-8M



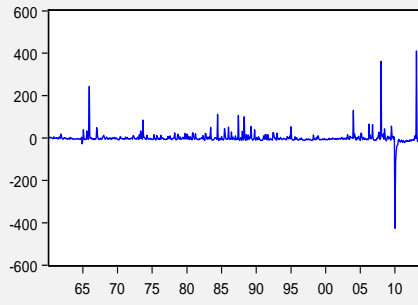
D3: 8-16M



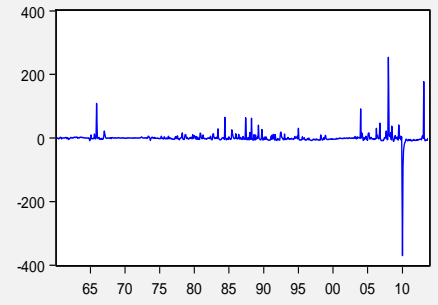
D4: 16-32M



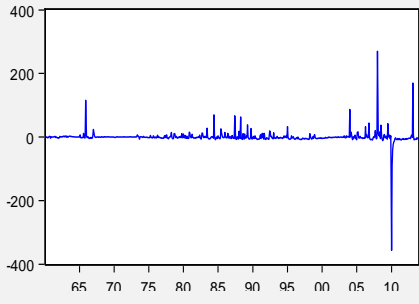
D5: 32-64M



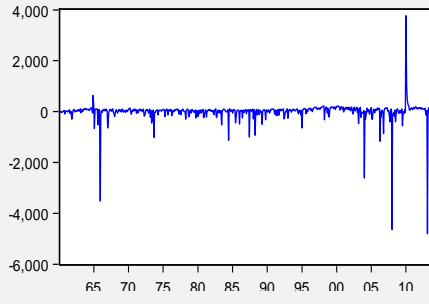
D6: 64-128M



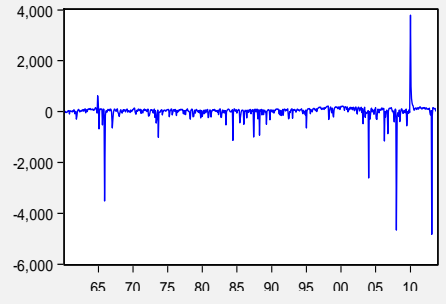
D7: 128-256M



D8: 256-512M

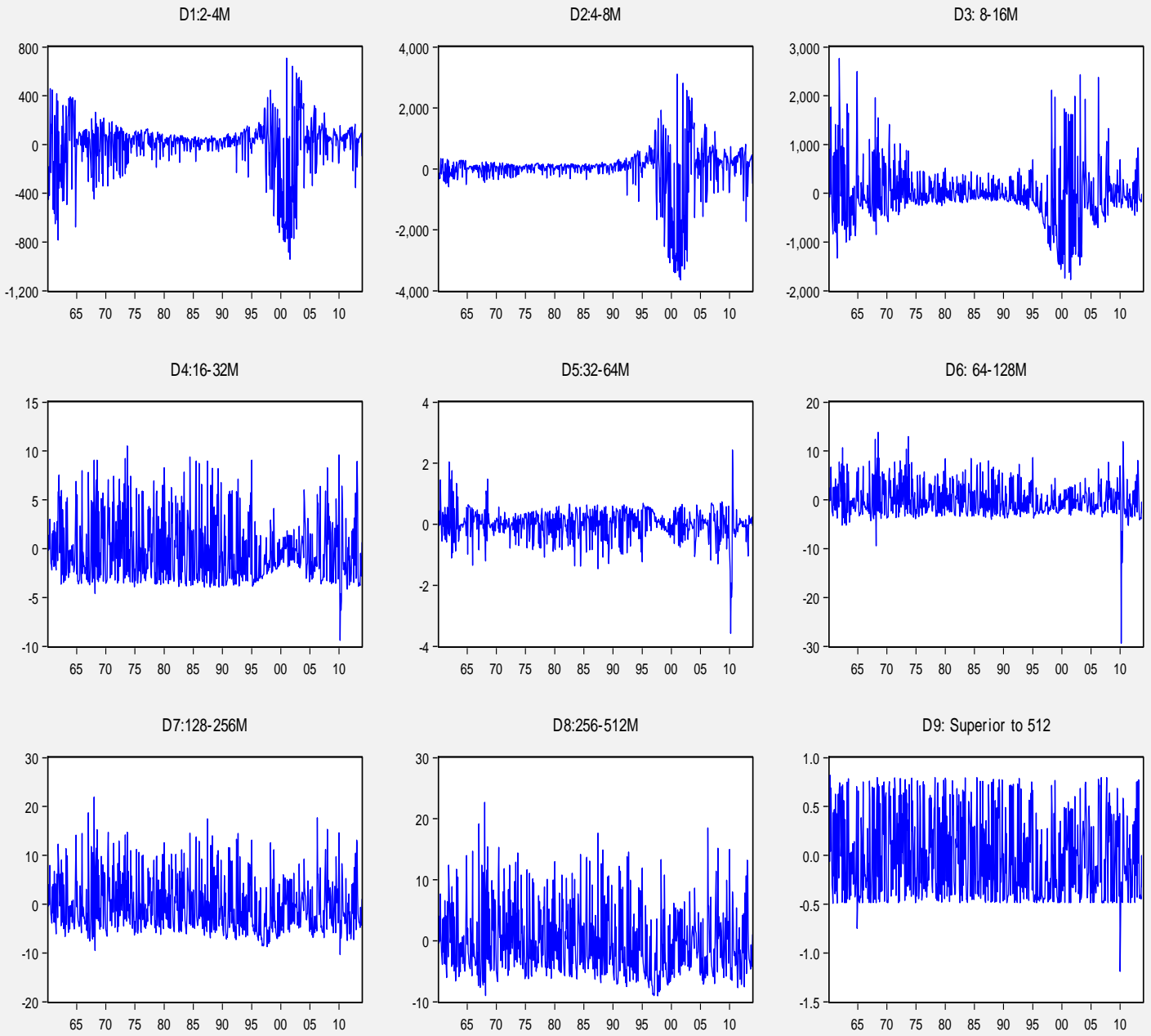


D9: Superior to 512M





Vol(INF)



Notes : INF: Logarithm of inflation rate ;Vol(INF): The logarithm of inflation volatility.

**Table 5. Nonlinear causality test**

Time domain	Frequencies								
D	D1	D2	D3	D4	D5	D6	D7	D8	D9
	2-4M	4-8M	8-16M	16-32M	32-64M	64-128M	128-256M	256-512M	>512M
<i>H<sub>0</sub>: Inflation does not cause inflation uncertainty</i>									
2.2813 (0.103)	2.6402* (0.0721)	2.94140* (0.0535)	0.14181 (0.8678)	3.4854* (0.0312)	10.414*** (4.E-05)	18.47*** (2.E-08)	0.64369 (0.5257)	0.47164 (0.6242)	0.45426 (0.6322)
<i>H<sub>0</sub>: Inflation uncertainty does not cause inflation</i>									
3.472* (0.031)	11.9*** (8.E-06)	27.22*** (4.E-12)	0.69752 (0.4982)	0.63073 (0.5325)	4.16137 (0.1160)	0.14653 (0.8637)	1.03703 (0.3551)	0.10315 (0.9020)	0.16803 (0.8454)

Notes: (.) : the p-value; p-value<0.01: \*\*\*; p-value<0.05: \*\*; p-value<0.1: \*.

#### 4.4. Discussion

The observed results highlight initially the utmost importance to account for nonlinearity when assessing the causal dynamic between inflation and its uncertainty. This relationship varies substantially among the specific frequencies involved. It behaves differently when moving from the short to the medium and the long term. Many factors can be advanced to explain these mixed findings. We organize them based on Korayem (1997)'s study into demand pull and cost push factors. We add the conflicting underlying objectives while attempting to explain the outcomes of transitional period (the aftermath of "Arab Spring").

In the short term (D1 and D2), the bidirectional causal connection between inflation and its uncertainty may be the result of several events, characterizing this period. Egypt has experienced external shocks that may have large inflation costs. The collapse in windfall revenues following the oil price crash, the development of dollar shortages, the cyclicity of fiscal policy and the inefficiency of financial intermediation (Panizza, 2001) have reduced the effectiveness of monetary policy in mitigating the detrimental effects of sudden shocks, generating a climate of uncertainty. Intuitively, the Egyptian economy was deeply dependent on rents including oil earnings, tourism and external debts that may delay considerably the very prime urgency of the implementation of such reform measures (Bromley and Bush, 1994).

In the medium term (D4, D5 and D6), the causal link that runs from inflation to inflation uncertainty may be substantially attributed to cost push factors such as the depreciation of domestic currency in February 1991 that has increased widely the prices of imported goods and then the domestic production costs (IMF, 1992). In addition, the value added tax on the prices of cigarettes, the price adjustments in some goods and services including telephone subscriptions, electricity and petroleum products in 1995. This has been sharply activated by the reduction of subsidies on fertilizers and pesticides and the elimination of subsidies on tea. This significant directional causality may be due also to demand pull factors including the remarkable fall in domestic credit and the unpleasant decrease of the growth rate from 25% in 1990 to only 1.5% in 1991 and increase again by 11.7% in 1993 (CBE report, 1994). Besides, the economic reform and structural adjustment program aimed at reaching economic stability and rectifying macroeconomic imbalances has reinforced cost push factors and impeded demand pull ones. Cost push factors have affected significantly the prices of goods and services, since it seems obvious that producers should expand their profit margins, in response to an increase in production cost. We should mention here that the sizable volatility of inflation was one of the failures of structural adjustment program in Egypt, as inflation rate increased remarkably from 1998 to 1995 by almost 13 % as average, despite the successfulness of fiscal policies adopted during this period in order to lessen deficit ratio of GDP from -2% to 3.4% in 1995 and to increase exports as a percentage of GDP from -10.562 % to 10.562 % under the same period (Talla and Emam, 2012).

In the long term (D7, D8 and D9), the fact that there is no significant interaction between inflation and the volatility of this variable seems very surprising. We expect that, under transitional period mainly characterized by great political instability, inflation may increase potentially uncertainty, without neglecting possible significant reverse nexus. This outcome may be a reflect of the various conflicting underlying objectives pursued by Egyptian authorities to avoid pitfalls and the harmful effects of instability. Of course, by the wake of the revolution and the gloomy outlook prevailed under this darkened period, all sectors of the Egyptian economy were heavily threatened. The economic growth was dropped, inflationary pressures were

seemingly considerable and the domestic currency was continuously depreciated. Egyptian pound was under great pressure in 2011 leading to almost 6 percent depreciation with monthly average exchange rate. Nevertheless, the lower dollarization level in 2012 prompted to a decrease in the pace of this depreciation (CBE Monthly Bulletin, 2011). With the aftermath of the “Arab Spring”, Egypt’s monetary policy was attempted to keep proper balance between attenuating inflationary pressures, preserving exports competitiveness, mitigating the volatility of domestic currency against dollar, enhancing credit growth and achieving sufficient liquidity level to avoid the remarkable economic growth slowdown. We cannot confirm that the policy pursued by Egyptian government seems beneficial and has succeeded to reach better inflation outcomes, since this country lacks institutional quality, coupled with a great weakness of public revenues and a sharp rise of fiscal deficit and debt stock. However, this unexpected finding can be only a reflect of contradictory underlying aims.

## **5. Conclusions and some economic implications**

One of the most substantial topics in monetary economics is to treat the directional causality between inflation and its uncertainty. Monetary authorities and advisors have been convinced that greater inflation volatility may threaten heavily the whole economy. Thus, there is a need to devote further efforts to fully comprehending the inflationary process so as to reach long-term price stability. The present research contributes to the existing literature on the nexus between inflation and inflation uncertainty by assessing whether there is a considerable change in the direction of causality over time. To this end, we decompose the causal connection between these variables into short-, medium- and long-run relationships via wavelet approach.

The relationship between inflation and inflation uncertainty appears bidirectional in the shortest time horizon (i.e., higher inflation increases inflation uncertainty and the latter fuels inflation), and unidirectional in the medium term (i.e., a significant link running from inflation to its volatility). Surprisingly, despite

the wake of greater political instability (the “Arab Spring”), any significant link has been observed in that period (i.e. there is no evidence of significant connection for the two directions).

In sum, the results seem inconclusive and ambiguous, highlighting the complexity of gaining clearer and solid insight into the focal issue. While trying to effectively tackle this debate controversy, we have decomposed the main causes behind these conflicting outcomes into demand pull factors (the fall in domestic credits and the drop of growth rate without forgetting the failure of economic reform and structural adjustment program), cost push factors (the price adjustments in some goods especially electricity and petroleum products and the reduction of subsidies on fertilizers, for instance) and conflicting underlying objectives pursued by Egyptian monetary authorities to keep balance between curbing inflationary tensions, lessening domestic currency’s volatility and boosting the economic growth down after the great political instability that unfolded in Egypt since 2011.

These findings may have important implications for Egyptian policymakers. It seems needed to enhance the credibility of monetary policy, to ensure effective allocation of resources and to mitigate the disruption in decisions. Due to the ineffectiveness of interest rate and the desire to balance between controversial objectives under great tension from 25<sup>th</sup> January 2011, the deeper adoption of countercyclical monetary policy using unconventional tools may be also beneficial.

While our paper does not say much about the routes through which inflation may affect differently inflation uncertainty and vice versa, it clearly indicates that this linkage changes over time and therefore it seems nonlinear. In a nutshell, we believe that the present study may be a valuable contribution to academics and advisors alike. Intuitively, the fact that there is no causal relationship between inflation and inflation uncertainty in the long-run (with the aftermath of revolution) does not essentially mean that the reforms implemented by Egypt to attenuate the damageable repercussions of political instability seem fruitful. This may be only a reflect of contradictory aims. Thus, enhancing compensatory financial system and

improving institutional quality<sup>4</sup> are needed, in transitional period, to help Egypt to go gradually towards long-run price economic prosperity.

Consequently, these conclusions may be also relevant for other Arab Spring countries as Tunisia and Yemen, for instance. The policymakers of these economies should devote more drastic and proactive efforts so as to keep the balance between achieving price stability and other objectives that may be contradictory.

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<sup>4</sup> According to Bouoiyour et al. (2014), developing economies with weaker institutional quality are often facing to several political shocks. Sudden events may prompt discontinuous monetary and fiscal policies leading to inflation extra-volatility.

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## Appendices

Table A.1. The choice of optimal GARCH model

GARCH extensions	AIC	BIC	HQ	RMSE	MAE
Standard GARCH $\sigma_t^2 = \omega + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2$	-5.0346	-4.8324	-4.8967	0.0142	0.0063
GARCH-M (GARCH in mean) $r_t = \mu_t + \varepsilon_t + \lambda \sigma_t^2$	-5.2579	-4.9254	-4.9856	0.0119	0.0069
C-GARCH (Component GARCH) $(\sigma_t^2 - \sigma^2) = \alpha \gamma (\varepsilon_{t-1}^2 - \sigma^2) + \beta (\sigma_{t-1}^2 - \sigma^2)$	-4.0987	-3.9866	-4.0001	0.0111	0.0073
QGARCH (Quadratic GARCH) $\sigma_t^2 = \omega + \sum_{i=1}^q \alpha_i (\varepsilon_{t-i} - b_i)^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2$	-4.5506	-4.4611	-4.5122	0.0112	0.0078
I-GARCH (Integrated GARCH) $\sigma_t^2 = \omega + \varepsilon_{t-1}^2 + \sum_{i=1}^q \alpha_i (\varepsilon_{t-i}^2 - \varepsilon_{t-1}^2) + \sum_{j=1}^p \beta_j (\sigma_{t-j}^2 - \varepsilon_{t-1}^2)$	-4.8231	-4.7892	-4.8923	0.0117	0.0081
A-GARCH (Asymmetric GARCH) $\sigma_t^2 = \omega + \sum_{i=1}^q \alpha_i ( \varepsilon_{t-i}  + \gamma_i \varepsilon_{t-i})^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2$	-5.3211	-5.2799	-5.2936	0.0110	0.0059
T-GARCH (Threshold GARCH) $\sigma_t^2 = \omega + \sum_{i=1}^q (\alpha_i  \varepsilon_{t-i}  + \gamma_i \varepsilon_{t-i}^+) + \sum_{j=1}^p \beta_j \sigma_{t-j}^2$	-4.8023	-4.7723	-4.7899	0.0118	0.0070
GJR-GARCH $\sigma_t^2 = \omega + \sum_{i=1}^q (\alpha_i + \gamma_i I_{(\varepsilon_{t-i} > 0)}) \varepsilon_{t-i}^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2$	-4.4425	-4.3922	-4.4135	0.0120	0.0068
GJR-PARCH (GJR power GARCH) $\sigma_t^\varphi = \omega + \sum_{i=1}^q (\alpha_i + \gamma_i I_{(\varepsilon_{t-i} > 0)}) \varepsilon_{t-i}^\varphi + \sum_{j=1}^p \beta_j \sigma_{t-j}^\varphi$	-4.6012	-4.3815	-4.5622	0.0123	0.0065
E-GARCH (Exponential GARCH) $\log(\sigma_t^2) = \omega + \sum_{i=1}^q (\alpha_i z_{t-i} + \gamma_i ( z_{t-i}  - \sqrt{2/\pi})) + \sum_{j=1}^p \beta_j \log(\sigma_{t-j}^2)$	-5.8921	-5.4972	-5.6122	0.0108	0.0052
P-GARCH (Power GARCH) $\sigma_t^\varphi = \omega + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^\varphi + \sum_{j=1}^p \beta_j \sigma_{t-j}^\varphi$	-4.0179	-3.9762	-4.0000	0.0115	0.0069
A-PGARCH (Asymmetric power GARCH) $\sigma_t^\varphi = \omega + \sum_{i=1}^q \alpha_i ( \varepsilon_{t-i}  + \gamma_i \varepsilon_{t-i})^\varphi + \sum_{j=1}^p \beta_j \sigma_{t-j}^\varphi$	-4.8097	-4.6255	-4.6812	0.0111	0.0063
NGARCH (Nonlinear GARCH) $\sigma_t^2 = \omega + \sum_{i=1}^q \alpha_i (\varepsilon_{t-i} - \kappa_i)^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2$	-4.5612	-4.3877	-4.4612	0.0017	0.0071

Notes:  $\sigma_t^2$ : conditional variance,  $\sigma_t$ : conditional standard deviation,  $\omega$ : reaction of shock,  $\alpha_0$ : reaction of shock,  $\alpha_i$ : ARCH term,  $\beta_i$ : GARCH term,  $\varepsilon$ : error term;  $I_t$ : denotes the information set available at time  $t$ ;  $I_{t-1}$ : denotes the information set available at time  $t-1$ ;  $z_t$ : the standardized value of error term where  $z_t = \varepsilon_{t-1} / \sigma_{t-1}$ ;  $\mu$ : innovation,  $\gamma$ : leverage effect;  $\sigma^2 = \omega / (1 - \alpha - \beta)$ : corresponds to the unconditional variance;  $b$ : quadratic order,  $\varphi$ : power parameter.