Paper submitted to the « 8es Journées de recherches en sciences sociales»

Title: DETERMINANTS OF FOOD PRICE VOLATILITY IN CAMEROON

KANE Gilles Quentin[1], Faculty of Economics and Management, University of Yaoundé II-Soa, Yaoundé-Cameroon. kanegilles@yahoo.fr

AMBAGNA Jean Joël, Sub-regional Institute of Statistic and Applied Economics, Yaoundé-Cameroon. joelambagna@rocketmail.com

MABAH TENE Gwladys Laure, Faculty of Economics and Management, University of Yaoundé II-Soa, Yaoundé-Cameroon. mabahlaure@yahoo.fr

[1] Corresponding author.

ABSTRACT:

The aim of this paper is to examine the determinants of food price volatility in Cameroon. Using data from International Monetary Fund (IMF) and the National Institute of Statistics in Cameroon, the empirical analyses were based on the ARMA, GARCH and GARCH-X methods. The most significant outcome of this study is that food price volatility in Cameroon is determined by local factors such as the volatility of the price of other agricultural goods , and not by factors coming from international market such as volatility of crude oil price and volatility of import cereals price. Therefore, it appears to be necessary in Cameroon to implement more specific development projects based on commodities rather than on export crops (cocoa and coffee) and improve the existing data collection system.

Key words: Food price volatility, ARMA, GARCH, GARCH-X, Cameroon.

JEL: Q11, Q18

INTRODUCTION

In the economic literature, it is commonly held that agriculture contributes significantly to economic development (Gollin *et al.*, 2002). Indeed, agricultural growth contributes more to development due to its significant multiplier effects. Thus, adequate level of price is necessary. In fact, this condition is one of the key issues in agricultural growth and, consequently, poverty reduction. Therefore, food price volatility is one of the threats in agriculture especially in developing countries (Subervie, 2007). Moreover, the question of food price volatility is in the very heart of the debate since the world food crisis of 2007-2008 and the resulting urban riots observed in about forty developing countries (Galtier, 2009).

In general, volatility of prices can be seen as a measure of price variability (Aizenman & Pinto, 2005; Balcombe, 2010; Piot-Lepetit & M'Barek, 2011). It is the deviation from a mean or a trend value. Price volatility also refers to sudden, unexpected, instable and large amplitude prices variation. Two types of volatility are generally analyzed in literature (Huchet-Bourdon, 2011; Tothova, 2011): realized or historical volatility and implied or future volatility. While historical volatility is related to the observed past trend of prices, implied volatility refers to the market expectations in terms of volatility at the beginning of the period.

When prices are volatile, households can reduce their inputs spending and this may have an impact on the quantity and quality of the food supply (IFPRI., 2011). Additionally, the food price volatility deteriorates the balance of payments of the government, for both net importers and net exporters of agricultural commodities and thus affects their investment capacity and ultimately growth.

Cameroon is one of those developing countries which were strongly affected by the 2008 food crisis. This has raised the debate on the role of agriculture in this country, food security and even food self-sufficiency to the extent that the country depends heavily on food imports. Indeed, in Cameroon, the agricultural sub-sector represents 75% of the primary sector and employs around 60% of the labor force (INS, 2010)[2]. This suggests that this sub-sector, indisputably, occupies a strategic place in the national economy in terms of foreign exchange earnings, employment generation, wealth creation, social stability, food security, food self-sufficiency and poverty alleviation. Agricultural supply in this country is characterized by two major features: firstly, production is growing at a rate of 2.4%, faster than the population growth rate (2.8%). Secondly, there was a decrease in rural population from 71.5% of the total

[2] National Institue of statistics.

population in 1976 to about 50% in 2008 (Medou, 2008). This had the effect to increase the gap between rural production (the main food provider) and national food demand. Therefore, in such a situation, the imports are necessary to balance supply and demand, which makes the country vulnerable to external shocks. Even if inflation was moderate during the 2000s, the low economic growth and the increase in prices of some essential goods help to erode the purchasing power of households (Awono & Havard, 2011). In this period, the agricultural price volatility has had dramatic consequences for state and household. For example, between 2005 and 2007, among others the price increased by 50%, 103%, 44.5% and 30% for rice, chicken, beef and fish respectively. More importantly, the price of a liter of palm oil has increased by 72% between June and December 2007 (Medou, 2008).

In other hand, at macro-level, to manage the problem of food price volatility, policy makers have to address the issue of its determinants, since the solutions for this problem depends largely on the nature and type of causes (Boussard, 2010). Therefore, an analysis to understand why prices evolve as they do and mainly what explains the variations in prices is a central question for African economies (Deaton, 1999). According to this last author, without such information, it would be very difficult to forecast the evolution of prices and consequently to produce good recommendations for economic policy. Thereby, the objective of this paper is to find out the factors that determine the volatility of food prices in Cameroon. The paper proceeds as follows: section 2 contains a review of literature; section 3 presents the methodology; section 4 looks at results; and finally section 5 concludes.

BRIEF LITERATURE REVIEW

Theoretically, at least there are two assumptions to explain food price volatility: the exogenous and the endogenous explanation. In accordance to the first one, price volatility is due to the nature in terms of weather shocks (Roll, 1984; Grimoux *et al.*, 2005). In this case, price volatility is caused by the variability of food production one year to another due to climatic variable which affect production (Galtier, 2009). Volatility is thus exogenous and stochastic. Ajakaiye and Adam (2011) following Abbot and Borot de Battisti (2011) have shown that, although the recent food price volatility in 2006 and 2008 can be explain mainly by a fundamental shifts in patterns of demand, the importance of climate change, the greater use of oilseeds and grains as oil substitutes, the importance of financial factors such as asset-price bubbles in commodity-backed securities is not negligible although remaining a subject of debate in literature. Apergis and Rezitis (2011) examine in the case of Greece, the relationship between food price volatility and short-run deviation of some macroeconomic factors such as money supply, real per-capita income, the real exchange rate, and the real deficit-to-income ratio in the GARCH and GARCH-X framework. The results showed the significant and positive effect for those deviations to the volatility of relative food prices. Thus, the authors suggest that it is crucial for policymakers to be aware of the degree of price volatility so as to be able to adopt appropriate hedging strategies. For Balcombe (2010) past volatility, transmission across price, stock level, oil price and exchange rate explain agricultural price volatility. Gerald (1996) shown that adopting economic reform was increase maize price volatility before slightly reduce price variability, using the Autoregressive Conditionally Heteroskedastic (ARCH) model. In this case, devaluation in 1983 due to structural adjustment in Ghana was briefly cause rise of maize price volatility. Finally, the study results suggest that to enhance market performance, government may reinforce and increase cash crop production. In addition Roll (1984) analyzes the relationship between orange juice production and weather in Florida shown that although the production is concentrated in the less temperature area, price volatility in market in the long term is only partially explained by the climatic risks. Suggesting that, others explanatories factors have to be taking into account.

According to the second hypothesis, food price volatility is endogenous and volatility is generated by market functioning (Boussard, 1996, 2007, 2010). Recall that agricultural production is characterized by uncertainty and risk such as production uncertainty, price uncertainty, technological uncertainty and policy uncertainty. Price uncertainty and production uncertainty therefore may cause price volatility (Moschini & Hennessy, 2000). Moreover, the endogenous explanation of food price volatility can theoretically base of cobweb model due to Ezekiel (1938). This model is based on a time lag between supply and demand decisions. Indeed, the reaction to the price changes in a market cannot be immediate; price and quantities variations are then drive by a succession of tests and error. The effect of price variation in one period, lead to generate supply variation in another period, and so on (Boussard, 2007). For example, the situation described by Ezekiel that, the production decision is made given the price of last year. If the price is high one year, the producer will react and produce more; finally the price next year will be lower than previous year when harvest will be sold. Thus the production will be lower; the price will increase, and so on. However, empirically the number of studies focus on the endogenous explanation of food price volatility is relatively low. For this instance, Mitra and Boussard (2011) in the endogenous explanation of the food price volatility suggest to model the market functioning by a chaotic model with storage. Using simulations on price series over 200 years, it was shown that it is still very difficult to decide between the endogenous and exogenous explanation of food price volatility by the experimental method. In Cameroon, Minkoua (2008) in the case of market gardeners and plantain farmers concludes that price volatility can be explain by the formation of expectations as the endogenous factor, using the cobweb approach. The last one also identified the perishability of the product, transport costs and policies, as exogenous factors.

Among the endogenous determinants of the food price volatility, the most controversial factor is certainly speculation (HLPE., 2011; FAO., 2012). Empirically, the verification of the hypothesis of a speculative bubble in the food commodities is relatively rare. Hernandez and Torero (2010) suggest that changes in spot prices for grains (wheat, corn and soybeans) are induced by changes in futures prices. In consequence, speculation by influencing prices on the futures market has an effect, at least indirectly on food prices. Gilbert (2010) documents evidence for speculative bubbles only in the case of soybean, but not in Both wheat and corn market in the period 2006 to 2008. When Sanders *et al.* (2008) are skeptic about the negative effect of speculation on the food price volatility observed in the recent years. Therefore, it seems like the effect of speculation depends on the products and markets in consideration.

While similar issues are addressed, this paper extends the existing research work in several important ways: our focus is on a different country and a wider variety of crops. In addition, while most studies of agriculture in the Cameroon revolve around the cash crops (cocoa and coffee), the importance of food crops such as grain, root and tuber cannot be overlooked. In this research work, we assume that the volatility of food prices in Cameroon can be caused by a set of domestic factors such as policies shocks but also by elements of the international markets which can be viewed as exogenous shocks on the prices formation.

METHODOLOGY

The data

Secondary data from the International Monetary Fund (IMF) and the National Institute of Statistics (NIS) were used. Data on the prices of international markets came from the world commodity prices of the IMF and data on the prices of different agricultural products in Cameroon came from the NIS. It is worth mentioning that price series used were real prices, deflated by the Consumer Price Index (CPI) as in the literature (Minten, 2006; Subervie, 2007; Minkoua Nzie, 2008). Indeed, the consideration of the CPI enabled us to integrate the time effect of the variation of the cost of life in our analysis. The study was carried out in the main markets of Cameroon, where the NIS collects monthly foodstuff prices in the markets of Douala, Yaoundé, Bamenda, Bafoussam and Garoua (figure 1 in the appendix). Data used were seasonally adjusted using the *census X-12 ARIMA* method of the US Census Bureau and the considered period of study is from January 1994 to December 2010, with 204 observations per variable.

The study focuses on two groups of products that account for about 50% of the total demand of food consumption in Cameroon and the most significant in terms of caloric contribution (Medou, 2008). Those groups are cereals that is the most imported in Sub-Saharan Africa (SSA) as indicated by Daviron *et al.*(2008), and roots and tubers. In terms of calories and protein contribution, these two groups account for 36.2% and 40% respectively for the first group, and 30,1% and 13,8% respectively for the second as noted by Medou (2008). Therefore, in this research work, we considered as cereals: rice and wheat[3] coming from the world market[4], and the local maize. In the group of roots and tubers, we considered: cassava, cocoyam and plantain, which are the most, used among others in subsistence farming in Cameroon[5]. On the other hand, products such as cassava and plantain are generally considered as the most emblematic foods in households' consumption in Cameroon, relative to imported food (Meuriot *et al.*, 2011).

Remark 1: the importance of climate data in such study is not the object of consensus in literature. Indeed, for some authors (Tothova, 2011; Rosa & Vasciaveon, 2012), climate data allow to take into account the effect of climate change, for some others it is not the case. Thus, in this study, we will not use such data. In fact, in Cameroon update climate data for the 5 regions in consideration are not available and the period of study seems to be relatively short to capture the effect of climate change knowing that this change takes time.

Remark 2: To convert international prices into domestic prices, we use the exchange rate USD/FCFA available in the IFS database of the IMF. Besides, it is worth verifying

[3] At local level, the price of bread is used as proxy for the price of wheat.
[4]The price of maize in world market is not include in our analysis because of the numerous used and transformation as suggested by Meuriot *et al.* (2011). Indeed, imported maize is majority used for the brewery industry and the breeding's. Thus, we assume that, the maize present in the market for human consumption come from local production.
[5]As noted by the National Institute of Statistics (2008), the most planted food for household among others is: maize (42.7%), cassava (28.3%), cocoyam (28.3%), and plantain (22.6%).

beforehand that international prices or at least their fluctuations are not explained by the fluctuations of the exchange rate, because this hypothesis has been the cause of a permanent debate in the literature. Following Cashin et al. (2004), we test the existence of a long term relationship using the standard co-integration approach of Engle and Granger (1987) for each price series of imported goods from world markets (rice, wheat and crude oil) in local currency unit and the exchange rate. No co-integration relationship between the price series of agricultural goods in local unit and the exchange rate were found. We can therefore accept the hypothesis that the volatility of the exchange rate does not influence significantly the volatility of international price series that are examined.

The measure of prices volatility

In literature, there are a wide range of methods that can be used to measure volatility. In general, among the most common measure of price volatility in economics, the coefficient of variation and the standard deviation of the price returns are found (Minot, 2012). The coefficient of variation (CV) is the ratio between the standard deviation of the variable of interest and its mean on a given period. It measures the spread of observed data, expressed in percentage of the mean, facilitates comparisons in terms of volatility between prices among different goods for different periods (Piot-Lepetit & M'Barek, 2011). Indeed, a higher coefficient of variation implies a wider spread of the series and consequently higher price volatility (Tothova, 2011).

The CV is calculated as follow:

$$CV = \frac{\text{standard deviation}}{\text{mean}} = \frac{\sqrt{\sum_{i=1}^{n}\left(p_i - \hat{p}\right)^2}}{\hat{p}} \quad (1)$$

Where p_i is the price level at period i and $\hat{p}$ is the mean of the price.

On the other hand, price volatility is increasingly measured by the standard deviation of the price returns, as in financial series (Aizenman & Pinto, 2005; Tsay, 2005; Gilbert & Morgan, 2011), this standard measure, in addition to being without unity, allows taking into account the direction taken by the price variability. Thus, we adopt this approach in our volatility model as usual in the literature (Gilbert & Morgan, 2010a; Minot, 2012; Rosa & Vasciaveon, 2012).

Following Minot (2012), price volatility is measured by:

$$Volatility = stdev(r) = \left[\sum \frac{1}{N-1} \left(r_t - \hat{r} \right)^2 \right]^{1/2} \qquad (2)$$

where $r_t = \ln(\frac{p_t}{p_{t-1}})$. r_t is the returns. and $\hat{r} = \sum \frac{1}{N} r_t$

It is common, in the literature, to use econometric models for volatility like in financial series in order to take into account the fact that volatility can change with time. These models are the Autoregressive Conditional Heteroscedasticitic model (ARCH) from Engle (1982) and the Generalized Autoregressive Conditional Heteroscedasticitic model (GARCH) from Bollerslev (1986).

A precision on the type of information used in the analysis of volatility is necessary. In fact, according to some authors (Moledina *et al.*, 2003; Aizenman & Pinto, 2005; Gilbert & Morgan, 2011), the measure of volatility of agricultural prices should take into account the fact that the different components of the price are predictable or not, especially its trend which should be extracted before any analysis. However, the major difficulty of such an approach is that the obtained measure of volatility depends heavily on the detrending model (Gilbert & Morgan, 2011; Huchet-Bourdon, 2011). In contrast, some authors like Piot-Lepetit and M'Barek (2011) suggest that agricultural prices series have different characteristics and properties from financial series. The distinction between the predictable and unpredictable components of the price series as in financial series is therefore not relevant. Also, we used price series (in log) in this study. The seasonal component of these price series is extracted beforehand to compute the price return or CV on which the analysis of the price volatility[6] will be made.

The Model

The followed stages were followed to analyze volatility in this research work:

(a) Descriptive statistic for each real price series and deseasonalization if necessary ;

(b) Standard unit root tests with and without change in regime (ADF, PP, KPSS and ZA)7 for each real price series ;

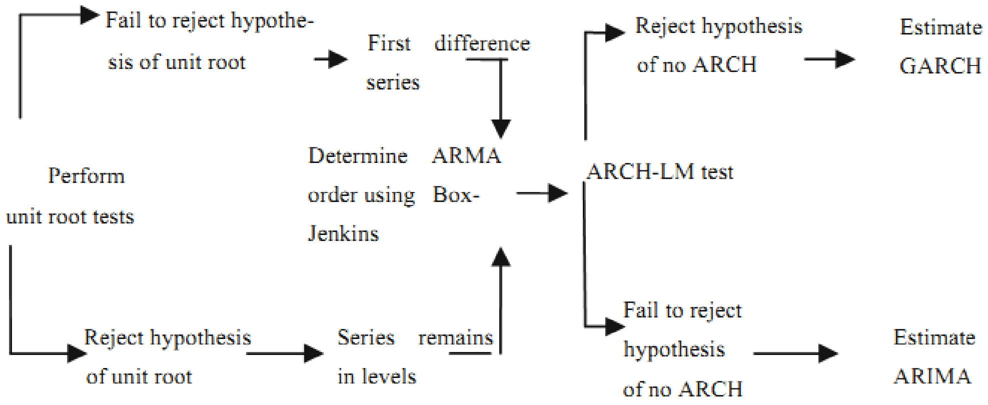
[6] In this case, volatility refers to the total variability in the price series studied.

[7] Dickey-Fuller unit root test (ADF); Phillips-Perron unit root test (PP); Kwiatkowski, Phillips, Schmidt and Shin unit root test (KPSS); Zivot and Andrews unit root test (ZA).

(c) Evolution of price dispersion over the period of study using CV ;

(d) Afterwards we applied the suggested procedure by Moledina *et al.*(2003) in returns series which is presented as follows:

Figure 2: Flowchart of methodology to compute conditional volatility



Source: Moledina *et al.* (2003)

Moreover, for the analysis of determinants of the price volatility, we put r_t and many explanatory variables into relationship as usual in literature. Thereby, we shall estimate for each series: a standard GARCH model, a GARCH-X model or an Autoregressive Moving Average (ARMA) model.

- **The ARMA model**

A stationary ARMA (p.q) model can be written as: $y_t = \phi_0 + \sum_{i=1}^{p} \phi_i y_{t-i} + \varepsilon_t + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j}$ (3)

Where y_t is a dependant variable, p and q are non-negative integers. t denotes the time period and the error terms in this model are assumed to be a Gaussian process with a mean of zero and a constant variance σ^2.

When taking into account the effect of others explanatories variables, the ARMA model become ARMA-X:

$$y_t = \phi_0 + \lambda d_t + X_t^{'}\eta + \sum_{i=1}^{p} \phi_i y_{t-i} + \varepsilon_t + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} \qquad (4)$$

where X_t is a column vector of explanatory variables and d_t is a set of dummy variable.

- **ARCH model**

Following Engle (1982), the ARCH model can allow to rewrite the error term of the ARMA equation as an autoregressive conditionally Heterosckedastic process. Hence an ARCH (m) is written:

$$y_t = \phi_0 + \sum_{i=1}^{p} \phi_1 y_{t-i} + \varepsilon_t + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} \qquad (5)$$

$$\varepsilon_t = z_t \sigma_t \qquad (6)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{m} \alpha_i \varepsilon_{t-i}^2 \qquad (7)$$

Where $\{z_t\}$ is a sequence of i.i.d random variables with a mean of zero and a unit variance.

$\alpha_0 \succ 0$, $\alpha_i \geq 0$ and the conditional variance σ_t^2 may change over time.

- **The GARCH model**

The GARCH model (p.q) is practically written in the same manner as the previous ARCH model, with the only difference being that the variance equation is written differently. Hence, the variance equation of a GARCH(m,s) model is written as

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{m} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{s} \beta_j \sigma_{t-j}^2 \qquad (8)$$

- **The GARCH-X model**

The GARCH-X model is a model that allows taking into account the effect of exogenous variables on volatility. It is a model that helps to give an economic and structural explanation to volatility (Engle & Patton, 2001). The use of this model can be justified by the fact that the standard GARCH model, by ignoring the information of other variables which are not taken into account in the measure of volatility can lead to biased estimates (Lamoureux & Lastrapes, 1990). In opposition to the standard GARCH model, the variance equation (9) of the GARCH-X model can be modelled as follow:

$$\sigma_t^2 = \alpha_0 + \pi d_t + \sum_{i=1}^{m} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{s} \beta_j \sigma_{t-j}^2 + \varphi X_t \qquad (9)$$

Where X_t is a column vector of explanatory variables and d_t is a set of dummy variable.

Variables definition

The choice made for the different variables in this study is justified by the fact that in literature those variables are the most used to explain the agricultural prices volatility. Otherwise, we should point out that the central hypothesis of this analysis is that the volatility of agricultural prices in Cameroon is explained by a set of domestic factors, but also factors that are external to the country and can be seen as external shocks in the constitution of agricultural prices in Cameroon. We distinguish in this study the following different explanatory variables:

- ***The volatility of crude oil price***: it captures the increase in the price of oil which causes an increase in the costs of fertilizers, mechanized agriculture, freight and transport costs (Ajakaiye & Adam, 2011). But also, the increasing use of bio-fuels which tighten the constraint of the supply of cereals in the world (Abbott & Borot de Battisti, 2011);

- ***The measure of the volatility of other agricultural products*****:** in case of speculation, the price volatility can be linked in different markets and its transmission among foodstuffs is generally expected to be positive (Balcombe, 2010).

- ***The economic policy/reformation***: dummy variables are included to capture the potential effect of the implementation of some public measures in relation to the supply of agricultural products. Hence, one of them captures the effect of the implementation in 2002 of the development strategy of the rural sector (D1)[8] which aimed at increasing the production and the other captures the suppression of duties and taxes when importing basic foodstuffs following the 2008 food crisis (D2)[9].

- ***The food pressure of the sub-region****:* a dummy variable allows taking into account the increasing pressure on the demand of domestic agricultural products coming from the sub-region is included (D3)[10]. In fact, some events such as the conflicts in Central African Republic, Chad, Congo, the crisis in Gabon and the expansion in the oil industry in Equatorial Guinea since 1998 can increase Cameroon food exportations (Dury *et al.*, 2004; Minkoua Nzie, 2008).

- ***The monthly price of fuel***: it is considered as a proxy of transport costs. In fact, Dury *et al.* (2004) points it out, the fluctuation of agricultural prices in Cameroon can be linked to

[8] D1 is a dummy variable which takes 1 after December 2001 and 0 otherwise.
[9] D2 is a dummy variable which takes 1 after February 2008 and 0 otherwise.
[10] D3 is a dummy variable which takes 1 after December 1997 and 0 otherwise.

the increase in the transportation costs due to the absence of roads maintenance and hence to the rise in fuels prices.

- ***Dollar exchange rate***: Exchange rate is considered among the financial variables that can influence the volatility of the agricultural prices in Cameroon, the exchange rate is considered. Financial markets are not developed in developing countries such as Cameroon. That does not allow taking into account the speculation effect like in developed countries. Added to that, for some people, the exchange rate can be seen as a volatility symptom and not as a cause of volatility (Abbott & Borot de Battisti, 2011). Also since our concern is about some import cereal and local commodities which are not subject to export, then the impact of exchange rate is asses indirectly using the price conversion for international currency (us dollar) to local currency.

RESULT AND DISCUSSIONS

In this subsection, for each real price series, we analyze the properties of data series by testing for the presence of unit root before presenting econometrics results. In addition, it seems important to notify that, the variable notation is constructed by two indications, namely: the commodity indication and the market indication (see appendix table1).

Summary of the data and seasonality tests

The results of the standard unit root test[11] suggest that most of real price series are stationary in level (appendix table2). Only maize, rice and bread in Yaoundé, and bread in Douala appear to be stationary in difference. Therefore, for series that are stationary in level, the shocks were transitory, in contrast to those with unit root, in which case, the shocks are permanent. In general, these results were similar when taking into account structural break. The propose break point suggest that in general, the price behavior were not affected by the 2007-2008 food crisis. The evidence of change in price series behaviour due to the recent food crisis was found only in Douala market.

Price dispersion over the period of study

It is largely argued in the literature that, food price volatility was the highest over the last thirty years. Thus, using Cameroon as the case study, we try to verify this hypothesis by

[11] The Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) , Kwiatkowski – Phillips - Schmidt - Shin (KPSS) and Zivot and Andrews (1992) test.

analyzing the price dispersion over the period of study. Coefficient of variation is used as measure of price dispersion. Additionally, the period of study were divided into two equal sub periods (January 1994 to June 2002 and July 2002 to December 2010). The results are presented in table 1.

In general price dispersion is higher during the first sub period than for the overall period and for the second sub period. The case of bread in Douala, rice in Yaoundé and Bamenda, rice and wheat in international markets are exceptions where price appear to be more dispersed in the second sub period which include the recent price surge than in the entire period. Moreover, price dispersion increased in the second sub period only for maize and rice in Yaoundé, maize and bread in Douala, cassava and rice in Bafoussam, rice in Bamenda, rice and wheat in international markets, where price dispersion for the remaining commodities decrease over the time but at various level. This result is similar for those obtained by Minot (2012), who suggests that there is no evidence of increasing food price volatility in Africa in the last decade as suggested in literature.

On the other hand, the highest price dispersion are for plantain and maize in Bamenda, and plantain in Bafoussam markets, while the lowest are for rice in Douala and Garoua markets. Among the commodities, price dispersion were highest for bread in Yaoundé, for cassava in Garoua, for maize in Bamenda, for cocoyam in Bamenda, for plantain in Bamenda and finally for rice in Yaoundé. To sum up, for each market, plantain was the highest dispersed commodity in Yaoundé, Bafoussam and Bamenda, maize in Douala and cassava in Garoua markets.

Table 1: Price dispersion 1994-2010

Commodity	Price series	Coefficient of variation (%)			% of change between
		1994m1 2010m12	*1994m1 2002m6*	*2002m7 2010m12*	
Bread	RBR_YDE	18,18%	15,28%	6,74%	-8,54%
	RBR_DLA	15,99%	13,38%	16,01%	**2,63%**
	RBR_BAF	11,98%	13,26%	10,26%	-3,00%
	RBR_BAM	11,40%	12,44%	9,44%	-3,00%
	RBR_GAR	13,43%	16,24%	8,94%	-7,30%
Cassava	CA_YDE	17,24%	20,09%	13,81%	-6,28%
	CA_DLA	15,32%	17,20%	13,01%	-4,18%
	CA_BAF	20,76%	18,05%	22,21%	**4,16%**
	CAWF_BAM	20,10%	26,44%	8,23%	-18,21%
	CA_GAR	24,95%	29,35%	19,91%	-9,44%
Maize	MA_YDE	16,87%	14,22%	16,61%	**2,39%**
	MA_DLA	20,14%	18,71%	19,23%	**0,52%**
	MA_BAF	23,11%	29,70%	13,78%	-15,91%
	MA_BAM	25,97%	25,89%	25,28%	-0,61%
	MA_GAR	24,99%	25,32%	24,77%	-0,54%
Cocoyam	COCO_YDE	17,90%	24,08%	7,86%	-16,22%
	COCO_DLA	17,14%	20,90%	11,86%	-9,04%
	COCO_BAF	20,45%	24,89%	11,22%	-13,67%
	COCO_BAM	24,23%	28,09%	14,49%	-13,60%
Plantain	PLA_YDE	19,85%	22,06%	16,82%	-5,23%
	PLA_DLA	11,01%	13,17%	8,22%	-4,96%
	PLA_BAF	29,82%	32,69%	23,04%	-9,65%
	PLA_BAM	30,86%	31,77%	22,28%	-9,49%
Rice	RI_YDE	14,48%	11,52%	15,95%	**4,43%**
	RI_DLA	9,06%	8,54%	6,61%	-1,93%
	RI_BAF	13,13%	9,86%	10,79%	**0,93%**
	RI_BAM	13,08%	9,84%	15,28%	**5,45%**
	RI_GAR	10,17%	10,43%	8,37%	-2,06%
Others	MIL_GAR	23,52%	27,18%	16,45%	-10,73%

Time series model for volatility

To analyze the determinants of food price volatility in Cameroon, we have applied econometric models as suggest earlier. Then, we have successfully estimated the ARMA and ARMA-X model when the ARCH effect was not found. Additionally, we have estimated the ARMA, the GARCH and the GARCH-X model to take into account the time varying volatility.

Since most of the real price series are stationary, it is obvious that most of the returns price series are stationary. In addition, the Box and Jenkins approach is used to determine the appropriate ARMA structure for each returns price series. Also, for each ARMA model a

Breusch-Godfrey Serial Correlation LM Test were applied and an ARCH LM test were used to test for ARCH effect. The summarize properties of all price returns, the ARMA process, the result of the ARCH LM test and the final process for each commodity are presented in the appendix table3. Theses result suggest that, the variance of returns series can be consider as constant over the time only for fourteen series among the twenty nine in consideration. Thus, for the remained fifteen returns series, the time varying volatility model can be used.

The estimate results for each econometric model are discussed.

- ***The ARMA result***

The result of ARMA-X model (table 2) suggests that, the suppression of import duties and taxes significant lower volatility only for the bread in Bafoussam and cassava in Douala. Also, the price volatility of cassava, cocoyam, maize, plantain and millet increase the volatility of maize in Douala, plantain in Yaoundé, cassava in Garoua, cassava and cocoyam in Douala, and cassava in Garoua respectively. But these effects have relatively low amplitude since the estimate coefficients are all lower than 0.50. These results suggest that these commodities can be view as complementary in each region. Opposite results are obtain for cocoyam and cassava in Douala, and for rice and cassava in Garoua suggesting that these commodities can be seen as substitutable product.

Table 2 : Estimate ARMA-X coefficients

	Bread	**Cassava**			**Cocoya**	**Maize**	**Plantain**		
	BAF	BAM	DLA	GAR	DLA	DLA	BAF	DLA	YDE
AR(1) ϕ_1	-0.05	0.17*	0.63***	0.49***	0.17**	-0.88***	-0.31***	-1.14***	-0.33***
AR(2) ϕ_2	-0.25***				0.13*	-0.2***	-0.25***	-0.40***	-0.18**
AR(3) ϕ_3	-0.16**						-0.17**		0.06
AR(4) ϕ_4	-0.19***						-0.12*		0.14*
MA(1) θ_1		-0.83***	-0.99***	-0.99***	-0.99***	0.73***		0.86***	
D2 λ_1	-0.01**		-0.01*						
R_CA η_1						0.20***			
R_CO η_2			-0.08**						0.47***
R_MA η_3				0.25***					
R_PLA η_4			0.23**		0.45***				
R_FU η_5		0.82**			0.46		-1.16***	-0.48**	
R_RI η_6				-0.37**					
R_MIL η_7				0.22***					
Prob(F)	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
LM Stat*	4.07	1.95	3.21	1.47	0.95	0.34	0.12	0.30	4.27

R_CA is the returns of cassava price series; R_CO is the returns of cocoyam prise series; R_MA is the returns of maize price series; R_PLA is the returns of plantain price series; R_FU is the returns of fuel price series; R_RI is the returns of rice price series and R_MIL is the returns of millet price series.

The growth rate of fuel have significant but opposite result in the returns series of some commodities. For example, the volatility in the fuel price increase volatility for cassava in Bamenda (0.82) and the opposite effect is observed for plantain in Bamenda (-1.16) and Douala (-0.48).

Finally two remarks among others in the results of the ARMA model when adding explanatories variables can be made. First, one can expect that, the returns (growth rate) of bread series is affect by the world price of wheat and crude oil. However, our results do not suggest such evidence implying that the price transmission between world market and Cameroonian market is low for wheat. This issue is beyond the scope of this paper. Second, we have to noted that it were not possible for some returns as bread in Douala, Garoua and Yaoundé, rice in Yaoundé and plantain in Bafoussam to estimate ARMA-X model since all the exogenous repressors were not significant.

- ***The GARCH result***

The GARCH results are present in the following two tables: table 3 and 4. For all returns series, the estimate coefficients satisfy the non-negativity condition. The results in table 3 suggest that a high level of persistence in volatility were found for some returns series as bread in Bamenda, millet in Garoua and cassava in Bafoussam where the sum of alpha and beta coefficient in the conditional variance equation (0.98, 0.96 and 0.82 respectively) is close to one. For some others returns series as cassava in Bafoussam and cocoyam in Bamenda, there were not persistence in volatility. Only the sum of the alpha and beta coefficient for cocoyam in Bafoussam and Yaoundé lead to explosive behavior.

For some returns series as bread in Bamenda, millet in Garoua and cassava in Yaoundé actual volatility is mainly explain by a past volatility relative to past innovations. These results are usual in GARCH model for volatility. However, the returns series for Cocoyam in Bamenda appear to be an exception where past innovation has had high effect than pas volatility in actual volatility (sum of alpha coefficients is more than sum of beta coefficients). Finally we have to note that, only the relative recent residuals have an impact on the current volatility for cassava in Bafoussam and cocoyam in Yaoundé. Indeed, those returns series exhibits a short memory process as suggested by its ARCH structure.

Table 3: Estimate GARCH coefficients for bread, millet, cassava and cocoyam

	Estimate coefficient	Returns price series						
		Bread	**Millet**	**Cassava**		**Cocoyam**		
		BAM	GAR	BAF	YDE	BAF	BAM	YDE
Mean process	ϕ_1			-0.66***	-0.94***	-0.43***	-0.97***	-0.46***
	ϕ_2						-0.42***	-0.47***
	ϕ_3						-0.22***	-0.67***
	θ_1	-0.44***	-0.25***	0.56**	0.99***		0.62***	0.34***
	θ_2	-0.15**				-0.57***		0.26***
	θ_3							0.80***
Conditional variance process	α_1		0.21***	0.23**	0.17***	0.63***		0.26**
	α_2							0.98***
	α_3							0.28**
	β_1	0.98***	0.75***		0.65***	0.37***	0.20*	

The results in the table 4 suggest that the volatility is explosive for some returns series as maize en Bamenda, Bafoussam and Yaoundé where it is persistent only for in maize in Garoua. Additionally, we can noted that past volatility have higher effect than past innovations only for maize in Bafoussam when this is not the case for the remained returns series presented in this table. ARCH structure was found for rice in Douala and Bamenda, and for maize in Bamenda.

To sum up, a graphical analysis of conditional standard deviation of all returns series after GARCH model (appendix table 4) tend to confirm the previous hypothesis that in Cameroonian market, the volatility of food commodity were not more volatile in the 2000 decade as in international market and some others developed countries. One explanation of this result can be the low volatility price transmission between world market and Cameroonian market for cereal. Also, this suggests that the transmission of price volatility is relatively low among the commodities in consideration but to confirm that, additional and more appropriate model have to be estimate. Food price volatility seems to be more important during the structural adjustment program period.

Table 4: Estimate GARCH coefficients for maize and rice

	Estimate coefficients	Returns price series							
		Maize				Rice			
		BAF	BAM	GAR	YDE	BAF	BAM	GAR	DLA
Mean process	ϕ_1	-0.10		-0.42***	-0.23***	-0.39***	-0.80***	-0.84***	-0.31***
	ϕ_2							-0.39***	-0.39***
	ϕ_3								-0.40***
	ϕ_4								-0.07**
	θ_1		-0.25***				0.43***	0.27	
	θ_2						-0.51***		
	θ_3						-0.21***		
Conditional variance process	α_1	0.53***	1.00***	0.39***	0.65***	0.29***	0.40***	0.51***	1.47***
	α_2								0.40***
	α_3								
	β_1	0.58***		0.32**	0.46***	0.26**		0.49***	

- ***The GARCH-X result***

As note in literature, the simple GARCH model for volatility does not really tell about what is the economic determinant of volatility. Then to overcome this weakness, as usual we tried to integrate some exogenous variables which can allow for economic explanation of volatility. There two major changes when integrating such variable in the GARCH model: first the persistence of volatility can change; second there are some variables which can significantly affect the volatility of price series (table 5 and table 6).

In some cases as for millet in Garoua and cassava in Yaoundé the inclusion of exogenous variables leads to lower the persistence on food price volatility. For some series as maize in Bafoussam and Bamenda, and rice in Garoua the volatility, the amplitude of volatility progress is lower by inclusion of exogenous variables from explosive to persistent. Also, the explosive behavior of volatility was lower by the GARCH-X specification in the case of cocoyam, rice and maize in Yaoundé. We have to note that, the world price of cereal and crude oil does not have significant effect on food price volatility in Cameroon. Indeed, when including these variables in a GARCH-X model, the effect was not significant. On the other hands, the result suggest that, the food price volatility is mainly explain by the volatility of others commodity as noted by Balcombe (2010). However, this effect is not the same in all case. There was some evidence of the effect of cereal price volatility on other commodity in the same local market. Then, the rice volatility increases the volatility of cassava. The same effect was observed for maize in Garoua, and for millet. This last result suggests that millet and rice can be seen as complementary product in Garoua.

The plantain volatility contributes to lower volatility for millet in Garoua, cocoyam in Bafoussam and maize in Bafoussam. According to this last result, plantain and millet in Garoua, plantain and cocoyam in Bafoussam and finally plantain and maize in Bafoussam can be seen as substitutable product.

The transportation cost in some cases can also affect significantly and positively the volatility of food price. This is the case for maize in Bamenda and Yaoundé. The explanation can be the fact that in this region, maize is produce relatively far from the town where the markets exist.

On the other hand, it is worth noting that the effect of policy measures, when it is significant was relatively low. First, the implementation of the development strategy of the rural sector contribute to lower volatility only in Garoua for millet and maize, in Bafoussam for cassava and cocoyam, and for cassava in Yaoundé contrary to what would be expected. This can be justified by the inefficiency of development project in rural sector. Second, the suppression of import duties and taxes on basic foodstuffs contribute to lower volatility only for maize, rice and cocoyam in Bafoussam; cassava and cocoyam in Yaoundé; and rice in Bamenda.

Table 5: Estimate GARCH-X coefficients for millet, cassava and cocoyam

	Estimate coefficients	**Returns price series**					
		Millet	**Cassava**		**Cocoyam**		
		GAR	BAF	YDE	BAF	BAM	YDE
Mean process	ϕ_1		-0.65***	0.95***	-0.25***	-0.81***	0.10
	ϕ_2					-0.37***	-0.48***
	ϕ_3					-0.23***	0.36***
	θ_1	-0.19**	0.57**	0.99***	-0.33***	0.45*	-0.13
	θ_2						0.64***
	θ_3						-0.02
Conditional variance process	α_1	0.12*	0.24**	0.15***	0.44***	0.21**	0.63***
	α_2				0.04		0.26**
	α_3						0.33**
	β_1	0.49***		0.53***			
	D1 π_1	-0.01**	-0.01***	-0.01***	-0.01***		
	D2 π_2			-0.001***	-0.01***		-0.001**
	D3 π_3					-0.02*	
	R_PLA		-0.01***		-0.01***		
	R_RI	-0.02***		0.01**			

φ_2 φ_3

Table 6 : Estimate GARCH-X coefficients for maize and rice

	Estimate coefficients	Returns price series							
		Maize				Rice			
		BAF	BAM	GAR	YDE	BAF	BAM	GAR	DLA
Mean process	ϕ_1	-0.14			-0.26***	-0.40***	-0.79***	-1.32***	-0.30***
	ϕ_2							-0.38***	-0.38***
	ϕ_3								-0.39***
	ϕ_4								-0.06***
	θ_1		-0.34***	-0.38***			0.44***	0.99***	
	θ_2						-0.48***		
	θ_3						-0.20***		
Conditional variance process	α_1	0.27***		0.13*	0.57***	0.14***	0.42***	0.30**	1.31***
	α_2								0.44***
	α_3								
	β_1	0.43***	0.80***	0.35***	0.50***	0.68***		0.58***	
	D1 π_1			-0.01***			0.01***		
	D2 π_2	-0.01***				-0.01***	-0.01***		-0.001**
	D3 π_3					0.001***			
	R_CA φ_1		-0.02***	-0.02***					
	R_PLA φ_2		-0.02***						
	R_RI φ_3	0.02**	-0.05***	0.09***					
	R_MIL φ_4			0.01				0.01***	
	R_FU φ_5		0.19***		0.03***				

To sum up, as shown by the summary table 7, in each market the couples of complementary and substitutable products are different. Indeed, this implies that in the case of complementary products for example, a rise of the prices on one product is also perceived on the others. In this case, government could concentrate only on one product and observed its evolution. A high volatility on one of these products would be an indication for a high volatility of the other; such information is important and can be useful to serve as an alarm and help the decision makers to be more effective in the fight against the food price volatility. In other hand, in the case of substitutable products, increase volatility in one product would lead to shortage in others due to great, sudden and rapid increase in demand. Therefore, for policy makers, such information would be significant and useful to be able to take adequate measures in convenient time.

Table 7: Summary results of complement and substitutable product in each market

Markets	Complements	Substitutes
Yaoundé	cocoyam - plantain cassava – rice	
Douala	cassava - maize plantain - cassava plantain - cocoyam	cocoyam - cassava
Bafoussam		plantain - cocoyam plantain - maize
Garoua	maize - cassava millet - cassava maize –rice rice –millet	rice - cassava plantain - millet

CONCLUSION

This paper examines the determinants of food price volatility in Cameroon. Using data from IMF and NIS, the empirical analyses were based on the methodology of ARMA, GARCH and GARCH-X approach. Some exogenous variables were used to find out the economic explanation of food price volatility. Differently from previous studies, we assume that food price volatility in Cameroonian market is a result of a set of domestic/local and external factors coming from world market.

Two main results were found. First, although the fact that there is a general tendency to assert that food price volatility has increased over time (Gilbert & Morgan, 2010b), we are unable to confirm this hypothesis. One possible explanation can be the fact that in Cameroon import cereals have many possible substitutes. However, to confirm that, more analysis which are under the scope of this study have to be done. Second, it were found that food price volatility in Cameroon is determined mostly by local factors such as the volatility of other products, and not by external factors such as volatility of crude oil and volatility of import cereals. This result suggests that, the price transmission between international and Cameroonian market in low for cereals. Therefore, it can be interesting in future research to analyze the cereals price transmission between world and Cameroonian market.

Two main recommendations can be suggested: first, it can be important to implement more specific development project based on others commodities such as local cereals, roots and tubers, export crops (cocoa and coffee) in Cameroon and find out how to improve the efficiency of existing development programs of agricultural sector. Second, it seems necessary to update existing data on commodity price and collected more details price series as consumers price and producer price which can be important for more specific analysis and information transmission among stakeholders.

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Appendix:

Figure 1 : Sample markets

Appendix Table 1: Variable notation

Commodity indication		**Market indication**	
Notation	**Explanation**	**Notation**	**Explanation**
RMA	real price of maize	YDE	Yaoundé market
RPLA	real price of maize	DLA	Douala market
RCOCO	real price of cocoyam	BAF	Bafoussam market
RCA	real price of cassava	BAM	Bamenda market
RBR	real price of bread	GAR	Garoua market

Appendix Table 2: Properties of real price series

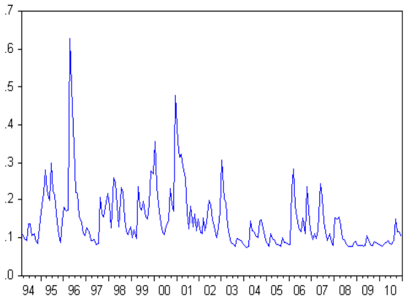
Commodity	Market	Integration order
Bread	Yaoundé	I(1)
	Douala	I(1)
	Bafoussam	I(0)
	Garoua	I(0)
	Bamenda	I(0)
Cassava	Yaoundé	I(0)
	Douala	I(0)
	Bafoussam	I(0)
	Garoua	I(0)
	Bamenda	I(0)
Maize	Yaoundé	I(1)
	Douala	I(0)
	Bafoussam	I(0)
	Garoua	I(0)
	Bamenda	I(0)
Cocoyam	Yaoundé	I(0)
	Douala	I(0)
	Bafoussam	I(0)
	Bamenda	I(0)
Plantain	Yaoundé	I(0)
	Douala	I(0)
	Bafoussam	I(0)
	Bamenda	I(0)
Rice	Yaoundé	I(1)
	Douala	I(0)
	Bafoussam	I(0)
	Garoua	I(0)
	Bamenda	I(0)
Millet	Garoua	I(0)

Appendix Table 3: Properties of returns price series

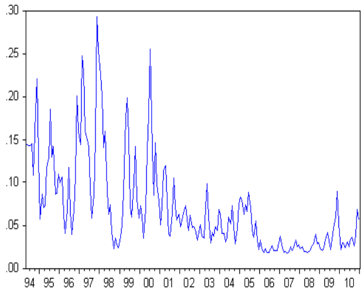
Commodity	Price series	I(d)	ARMA process	ARCH LM test	Process of series
	R_RBR_BAF	I(0)	ARMA(4,0)	Homoskedasticity	ARMA(4,0)
	R_RBR_BAM	I(0)	ARMA(0,2)	Heteroskedasticity	GARCH(0,1)
Bread	R_RBR_DLA	I(0)	ARMA(1,1)	Homoskedasticity	ARMA(1,1)
	R_RBR_GAR	I(0)	ARMA(3,0)	Homoskedasticity	ARMA(3,0)
	R_RBR_YDE	I(0)	ARMA(1,0)	Homoskedasticity	ARMA(1,0)
	R_RCA__GAR	I(0)	ARMA(1,1)	Homoskedasticity	ARMA(1,1)
	R_RCA_BAF	I(0)	ARMA(1,1)	Heteroskedasticity	GARCH(1,0)
Cassava	R_RCA_DLA	I(0)	ARMA(1,1)	Homoskedasticity	ARMA(1,1)
	R_RCA_YDE	I(0)	ARMA(1,1)	Heteroskedasticity	GARCH(1,1)
	R_RCAWF_BAM	I(0)	ARMA(1,1)	Homoskedasticity	ARMA(1,1)
	R_RCOCO__BAF	I(0)	ARMA(1,2)*	Heteroskedasticity	GARCH(1,1)
Cocoyam	R_RCOCO__BAM	I(0)	ARMA(3,1)	Heteroskedasticity	GARCH(1,0)
	R_RCOCO__DLA	I(0)	ARMA(2,1)	Homoskedasticity	ARMA(2,1)
	R_RCOCO__YDE_SA	I(0)	ARMA(3,3)	Heteroskedasticity	GARCH(3,0)
	R_RMA__BAF_SA	I(0)	ARMA(1,1)	Heteroskedasticity	GARCH(1,1)
	R_RMA__BAM_SA	I(0)	ARMA(0,1)	Heteroskedasticity	GARCH(0,1)
Maize	R_RMA__DLA_SA	I(0)	ARMA(2,1)	Homoskedasticity	ARMA(2,1)
	R_RMA__GAR_SA	I(0)	ARMA(0,1)	Heteroskedasticity	GARCH(1,1)
	R_RMA__YDE_SA	I(0)	ARMA(1,0)	Heteroskedasticity	GARCH(1,1)
	R_RPLA__BAM	I(0)	ARMA(2,0)	Homoskedasticity	ARMA(2,0)
Plantain	R_RPLA__DLA_SA	I(0)	ARMA(2,1)	Homoskedasticity	ARMA(2,1)
	R_RPLA_BAF_SA	I(0)	ARMA(4,0)	Homoskedasticity	ARMA(4,0)
	R_RPLA_YDE_SA	I(0)	ARMA(4,0)	Homoskedasticity	ARMA(4,0)
	R_RRI___BAM	I(0)	ARMA(3,1)	Heteroskedasticity	GARCH(1,0)
	R_RRI___GAR	I(0)	ARMA(2,1)	Heteroskedasticity	GARCH(1,1)
	R_RRI__BAF	I(0)	ARMA(1,0)	Heteroskedasticity	GARCH(1,1)
	R_RRI__DLA	I(0)	ARMA(4,0)	Heteroskedasticity	GARCH(2,0)
	R_RRI__YDE	I(0)	ARMA(2,1)	Homoskedasticity	ARMA(2,1)
Others	R_RMIL_GAR	I(0)	ARMA(0,1)	Heteroskedasticity	GARCH(1,1)

ARMA(1,2)* correspond to the ARMA(1,2) model where the first component of the moving average part is remove to eliminate serial correlation.

Appendix Table 4: Evolution of conditional standard deviation for GARCH process



R_RCOCO__BAF



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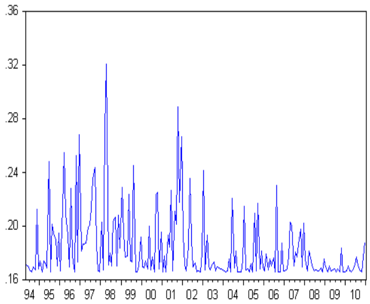

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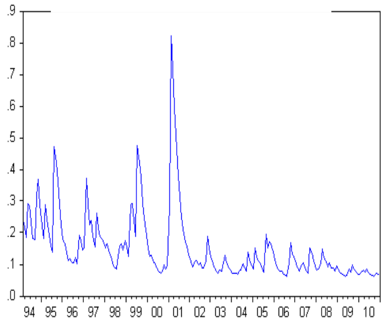
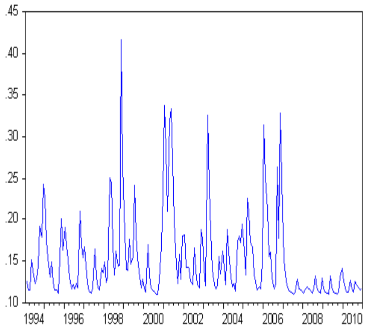
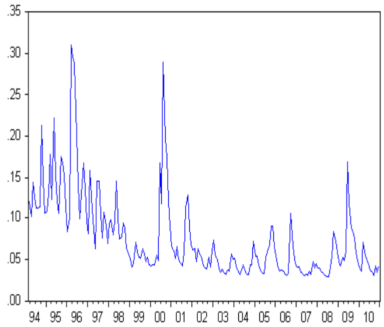


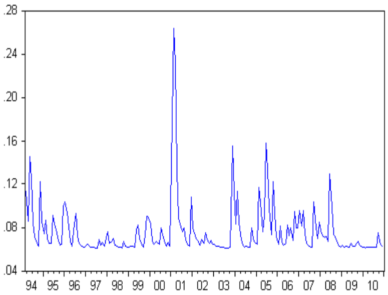
R_RMA__BAF_



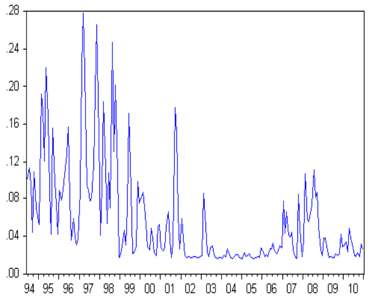
R_RMA__GAR_S



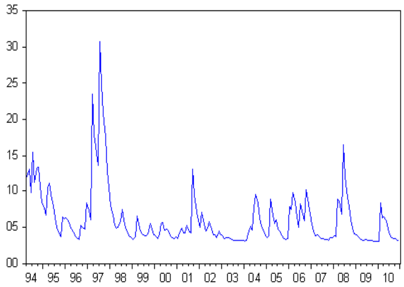
R_RMA__YDE_SA



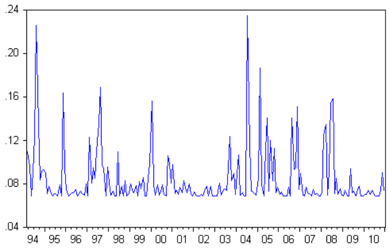
R_RRI__BAF



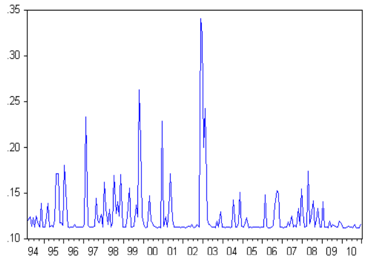
R_RRI_DL



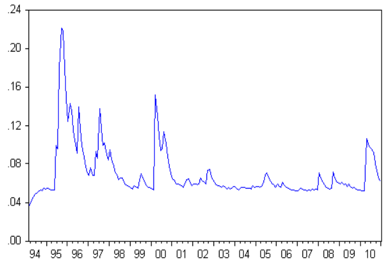
R_RRI___GAR



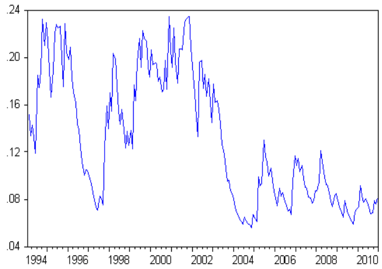
R_RRI___BAM



R_RCA_BAF



R_RCA_YDE



R RMIL GA