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# Analysis of the Volatility of the Price of Cassava in Cameroon: Implications for Food Security

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***Abstract:*** With a contribution of up to 71% to CEMAC production, Cameroon is one of the major producers of cassava and taro, accounting for more than 83% of root and tuber production. It is the 11th largest producer in the world and the 4th in Africa. Cassava is a vital food source for over 500 million people, ranking as the third-largest source of calories in the tropics after rice and maize. Its importance as a source of income for the majority of poor rural farmers in Cameroon cannot be overstated. However, there has been a persistent increase in the prices of cassava and other food commodities in Cameroon. This study was designed to investigate the determinants of cassava price volatility in Cameroon over the period 1994-2022. The TAR-MTAR method was employed in this study. Our results showed that cassava prices increased significantly by an average of 46 % annually, with a volatility level of 30.8% annually and 177.8% over the entire period (1994-2022). This indicates that cassava prices have been rising rapidly and unpredictably, which can have various implications for consumers, farmers, and the economy as a whole.

The research demonstrated that cassava price volatility occurred at the beginning, middle, and end of the year due to factors such as climate change, cassava yield, and interest rates. It has been suggested that the government should implement a mapping policy and selling models to ensure a stable supply of cassava.

***Keywords***: Volatility, Cassava, Food security, Cameroon.

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## 1. Introduction

Agricultural commodities, especially food, are essential to meet national food needs and rural livelihoods (OECD-FAO, 2024; Lestari *et al.*, 2022). The availability of these commodities is necessary to ensure the daily food consumption of society and to ensure a consistent food supply (Shen *et al*., 2024). However, agricultural commodities often experience price fluctuations in their development Agricultural commodities often experience price fluctuations in their development (Antwi *et al*., 2021; Kumari *et al*., 2019; Nigatu and Adjemian, 2020; Nugroho *et al*., 2018; Sativa *et al*., 2017; Lestari *et a*l., 2022; Smith *et al*., 2024). Food security is influenced by the transmission and fluctuations in food prices, and the latter has long been a recurring problem in many African countries (Chitondo *et al*., 2024; Onumah *et al*., 2022; Hamilton *et al*., 2020; HLPE, 2011; Olila *et al*., 2016; Onyuma *et al*., 2006; Sousa, 2017). Previous studies (Temple, 2006; Nzossie, 2013; Kane *et al*., 2015) reported alarming increases and volatility in staple food prices in Cameroon, coupled with inadequate market price transmission, that plunged millions of people into food insecurity, worsening the living conditions of many people (Akpan and Udoh, 2009).

Food price volatility poses a significant threat to agriculture, especially in developing countries (Subervie, 2007; OECD, 2011). This volatility can stem from various factors such as inadequate transport infrastructure, communication services, government intervention mechanisms, the complexity of marketing channels, and contractual agreements among economic actors (Meyer and von Cramon-Taubadel, 2004). These imperfections are exacerbated by irregularities in the number and transparency of market participants, which alter market structures and subsequently affect price determination. Agricultural markets often deviate from the conditions of pure and perfect competition (Guerrien, 2006), leading to non-reciprocal relationships in commodity price movements across different stages of the marketing chain.

Understanding the level of market integration within Cameroon, shaped by its unique geographical characteristics, is crucial. Equally important is discerning the factors that influence why some regions exhibit high spatial integration while others show weak or no integration at all (Gonzalo *et al*., 2012).

Furthermore, weak integration implies limited domestic supply responses to increasing commodity prices. A non-integrated market operates blindly, with producers unable to discern highly valued global market trends, potentially leading to suboptimal decision-making and inefficiencies (Gonzalo *et al*., 2012). Vavra and Goodwin (2005) observed that the speed of market adjustments to shocks hinges on the actions of market agents—such as wholesalers, distributors, processors, and retailers—who facilitate transactions across market levels.

In an unintegrated market, incomplete price information may distort production decisions. Market price instability can profoundly impact food security, particularly affecting the access of poor households to food in the short term and influencing producers' incentives to invest and enhance production in the long term (Galtier, 2009). In Cameroon in particular, fluctuations in these prices, which exacerbate situations of food insecurity for the poorest households, have raised debate about the role of agriculture in this country, food security, and even food self-sufficiency insofar as the country is heavily dependent on food imports (Minkoua, 2018; Kane, 2018). The formulation of policies to stabilize food markets is a key issue for long-term agricultural development through the control of price movements, which are recognised in the literature as affecting farmers' technological investments. Implementing these policies requires prior identification of the various factors that influence food prices. Food price volatility is a major agricultural phenomenon, particularly in developing countries, given that agriculture is the main source of income for populations (Prakaash, 2011). Agricultural price volatility is a phenomenon that has often occurred in the past but has never reached current figures (Lanfranchi *et al.*, 2019). Today, this condition has become a structural feature of global agricultural markets. According to Ceballos *et al*. (2017), the problem of agricultural price instability can be attributed to one main factor linked to the evolving dynamics of world markets. This price phenomenon has received considerable attention in the economic literature (Lloyd, 2017; Assefa *et al.*, 2015; Frey & Manera, 2007; Meyer and Cramon-Taubadel, 2004), which examines the links between prices at all stages of the agricultural market.

Agricultural price volatility is a phenomenon that has often occurred in the past but has never reached current figures (Lanfranchi *et al*., 2019; Pan and Zheng, 2023). Today, this condition has become a structural feature of global agricultural markets. According to Ceballos *et al.* (2017), the problem of agricultural price instability can be attributed to one main factor linked to the evolving dynamics of world markets. This price phenomenon has received considerable attention in the economic literature (Lloyd, 2017; Assefa *et al*., 2015; Frey and Manera, 2007; Meyer and Cramon-Taubadel, 2004), which examines the links between prices at all stages of the agricultural market.

This study also contributes to the existing literature on the transmission of agricultural commodity price volatility in developing countries. In particular, volatility transmission models may vary from one country to another due to differences in institutional and economic development. While much of the current literature has focused on developed countries capable of large-scale production through advanced technologies and efficient business operations, such as Germany (Assefa *et al*., 2017) and the United States (Buguk *et al*., 2003), few studies have focused on developing countries with the characteristics of a decentralized, smallholder economy. Our results provide new Cameroonian evidence for this strand of the empirical literature. Furthermore, we contribute to the literature on the dynamics of price volatility in agricultural commodity markets in Cameroon (Njoda and Nkot, 2017; Minkoua *et al*, 2018; Kane *et al*, 2019).

## 2. Conceptual Framework

The schema depicts that whether or not markets are integrated depends on several factors. These factors are at the heart of the search for better prescription in order to improve the efficiency of the markets.

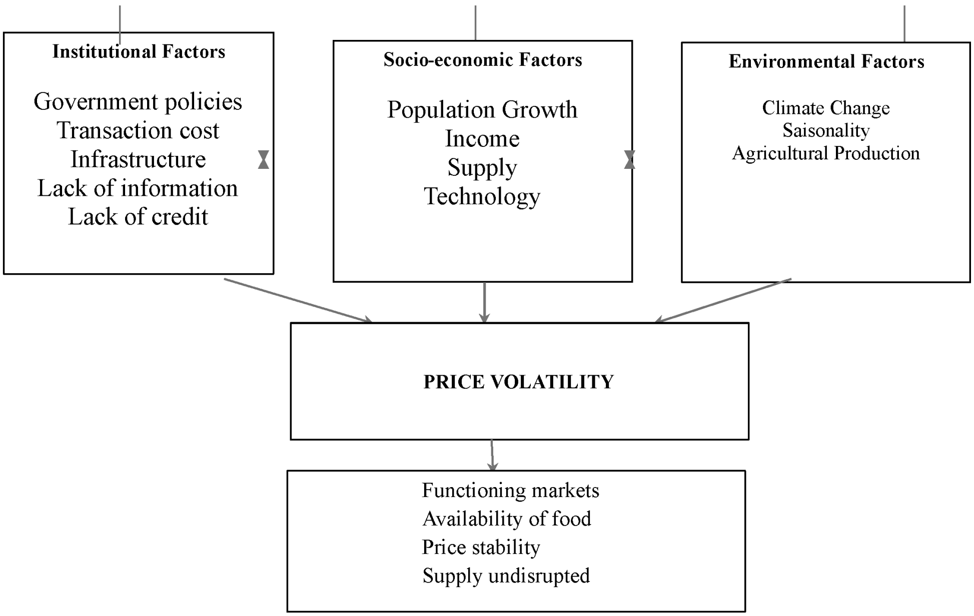


**Figure 1: Conceptual Framework**

*Source:* Author's conceptualization, 2022.

The heed to these strategies depends on a number of factors that affect the market integration system. These include institutional, environmental and socio-economic factors (Figure 1). Institutional factors include government policies, lack of information, lack of basic infrastructure such as all-weather roads, storage facilities, transport, lack of credit, etc. Most assessments of constraints for farmers indicate that the lack of rural transport is a major obstacle for farmers seeking to market their surplus crops. Limited local transport means not only increased costs but also that traders are less willing to travel, market information is more limited and farmers' choice of marketing channels is very limited, which greatly reduces their ability to sell their produce, which greatly reduces their bargaining power. While socio-economic factors include: Population growth, income, supply and technology. Finally, environmental factors include: Climate change, seasonality, and agricultural production.

Therefore, when two markets are integrated due to functioning markets, Availability of food, Price stability, supply undisrupted, it means that government policies need to be set up to improve transport and communication infrastructure, and cassava price information needs to be adequate for market participants, which leads to decisions that contribute to efficient outcomes or efficient markets. Improving transaction costs can increase the participation of market agents and improve the flow of cassava from surplus to deficit areas.

To achieve this objective, the government may resort to price controls, which can be seen as a price guarantee policy. In one case, the government may set an artificially high price (floor price) to ensure a higher income for producers than in the case of a free market. In another case, the government may impose artificially low prices (price ceiling) to ensure that consumers receive a lower income than in the case of a free market and thus increase their purchasing power. The alternative to price control policies is the "price band" (Holt and Aradhyula, 1990).

In the latter case, the government only intervenes if prices fluctuate outside a defined price band. Thus, to stabilize prices when they fluctuate outside the band, the government can use, among other things: imports, exports and stock changes (De Janvry *et al*., 1995). Indeed, such measures do not allow prices to fully play their role as a 'signal' to actors; a signal that allows economic agents to efficiently use their scarce resources (Petkantchin, 2006). Thus, instead of stabilizing prices in agricultural markets, these measures can act as distortions of the market and make it more volatile, mainly due to overproduction in one case, and in the other, it can discourage investment, innovation and production. On the other hand, other economic policy measures, such as taxes and subsidies, market-oriented government programmes, and loan ratios have been mentioned as determining food price volatility.

## 3. Methodology

### *3.1. Source of data*

Cameroon is located between Latitude 2° N to 13° N: Longitude 8° 25° E and 16° 20° E in the Central African sub region. It opens to the Atlantic Ocean in the West with a total coastline of 402 km. It is bounded to the west by Nigeria, North-east by Chad, South by Gabon, DR Congo, and Equatorial Guinea and to the East by Central African Republic. It has a total surface area of 475 650 km 475,650 km which is distributed into five agro ecological zones in ten geographical regions (MINFOF, 2018) (MINFOF, 2018). It is composed of 10 regions with five major agro ecological zones Most notably the Sudano-Sahelian, High guinea savannah, western highland, Monomodal Humid Rainforest, and the Bimodal Rainforest (Fig. 1). This agro ecological diversity permits the conditions necessary for the growth of most crops which characterize other African nations hence the name "Africa in miniature" (MINEPDED, 2017). This natural virtue over other African nations, makes Cameroon has become the breadbasket of Central Africa and supplies Gabon, Central African Republic, Equatorial Guinea, and Tchad as well as neighboring Nigeria to the west.

Our study is conducted in the West, Northwest (Western highlands), and the Littoral and South-West (Monomodal Humid Rainforest), the Centre, East

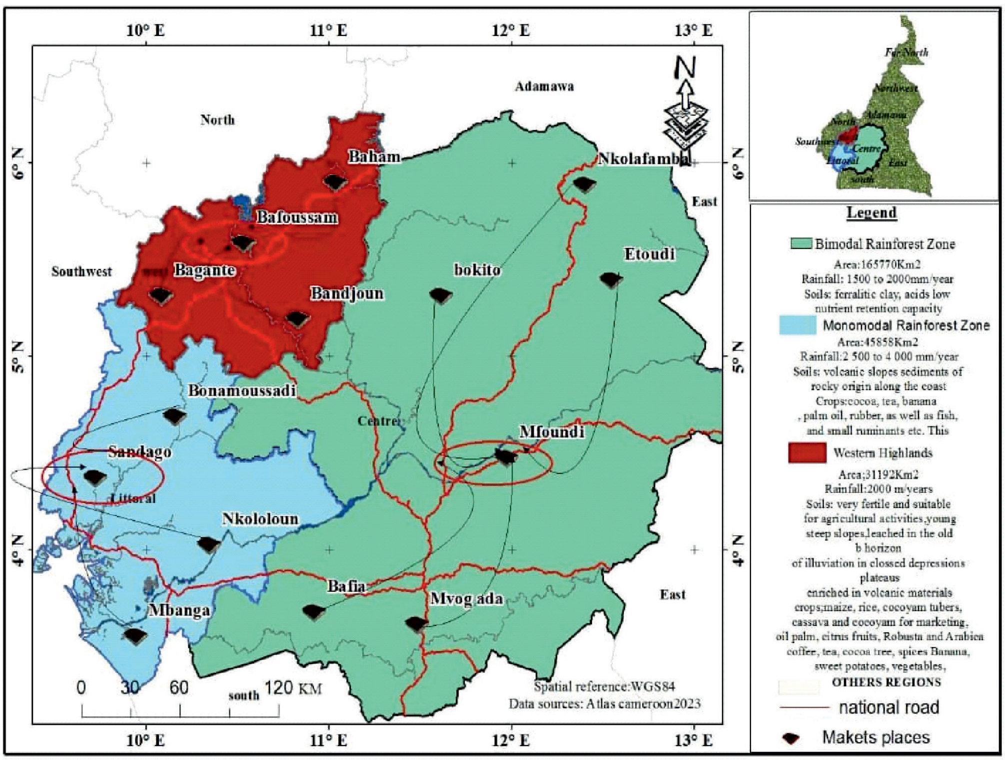


**Figure 2: Map of Cameroon showing selected study area and location of markets**

*Source:* Constructed from Atlas-forest dataset Cameroon, 2023 and South (Bimodal Humid Rainforest) regions of Cameroon (MINADER, 2010; MINRESI, 2007). These three agroecology are chosen because they have a characteristic tropical climate of two seasons (a rainy season and a dry season) which permits the cultivation of cassava (Molua and Lambi, 2015). Apart from the favorable climate for cassava production, these areas also harbor the largest markets for retail and wholesale of cassava produced (Yaoundé, Douala and Bafoussam) and its derivatives. Furthermore, the "main" markets of these areas are interconnected by accessible roads. Thus, making it ideal for our analysis.

It covered traders who sell and buy cassava in the study area. Secondary data used in this study was obtained from the National Institute of Statistics (NIS) are used to analyze the determinants of food price volatility in Cameroon. We consider the period from January 1994 to December 2022 and was divided into three strata (Regions). Secondary data from the National Institute of Statistics (NIS) were used to examine the possible threshold effects on price transmission two threshold cointegration models, namely the threshold autoregressive (TAR) model and the momentum-threshold autoregressive (M-TAR) model are used. (Enders and Siklos, 2001) established these threshold cointegration tests where negative and positive deviations from the long-run equilibrium are not adjusted in the same way, that is, there is asymmetry in long-run adjustment to the equilibrium (Ndoricimpa and Achandi, 2014). The lag of the variables is used in the TAR model, whereas previous period's changes are preferred in the M-TAR model as a threshold variable.

To model the possibility that the short-run dynamic relationship acts in diverse ways depending on the magnitude of deviation from the equilibrium, threshold cointegration is used. The TAR model captures asymmetrically "deep" movements in the series, while the M-TAR model captures asymmetrically sharp or "steep" movements.

(Enders and Siklos, 2001) proposed the following steps to test for threshold co-integration using TAR and M-TAR models. In the first step, the following long-run equilibrium relationship is estimated:

$$P^1{}_t = \beta_0 + \beta P^2{}_t + \mu_t \qquad (1)$$

where, $P^1{}_t$ and $P^2{}_t$ are the price of rice in two markets within a pair, say, farm and wholesale price or retail and wholesale price, respectively. μ is the disturbance term. Then the following equation is estimated using Ordinary Least Squares (OLS):

$$\Delta\mu t = It\varrho 1\mu t{-}1 + (1 - It)\varrho 2\mu t{-}1 + \Sigma ik{=}1\ \beta\Delta\mu t{-}i + \varepsilon t \qquad (2)$$

Where, $\mu_t$ is the residual series from Equation (7), $k$ is the lag length and $I_t$ is the Heaviside indicator

Function such that:

$$( 1\ if\ \mu^{\ t-1 \geq}\lambda$$

$$I_{t\,=}\ \text{For TAR model} \qquad (8)$$

$$0\ if\ \mu_t{-}_1 < \lambda$$

And

$$I_t = \begin{cases} 1\ if\ \Delta\mu_{t-1} \geq \lambda \\ 0\ if\ \Delta\mu_{t-1} < \lambda \end{cases} \text{For M-TAR model} \qquad (3)$$

The lagged dependent variable values are added in order to ensure that the residuals are white noise. The lag lengths are selected using AIC and SBIC.

Finally, TAR and M-TAR co-integration and adjustment process are specified as:

$$(\rho\ \mu - + \varepsilon\ if\ \mu - \geq \lambda)$$

$$\Delta\mu_{t\,=}\ 1\ t\ 1\ t\ t\ 1\ \rho_2\mu_t - 1 + \varepsilon_t\ if \quad \text{For TAR model and;} \qquad (4)$$

$$\mu_t - 1 < \lambda$$

The number of lags k to include in the TAR and M- TAR models were also selected by using TAR and M-TAR models. The optimal threshold value $\lambda$ minimizing the residual sums of squares was estimated using (Chan's, 1993)

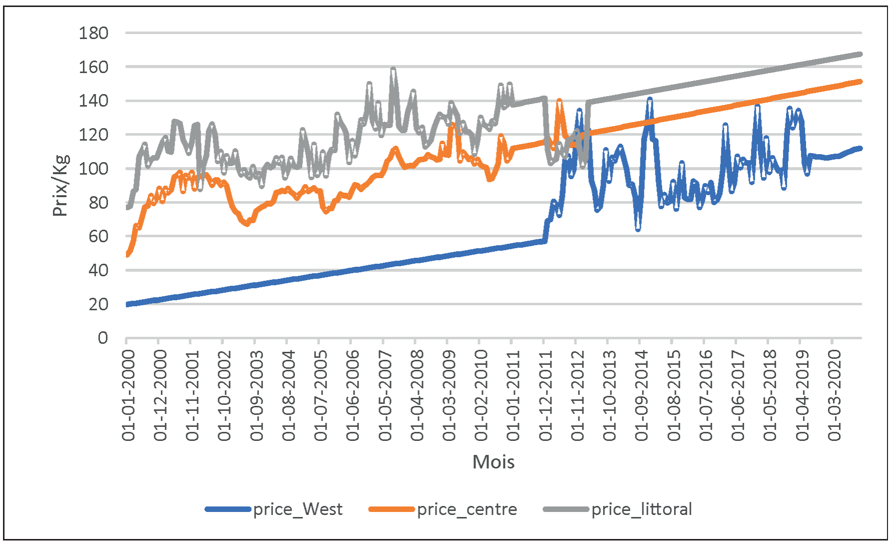


**Figure 3: Evolution of cassava prices on the West, Centre and Littoral markets**

*Source*: NSI/ Author (2022)

method. Given the alternative models, model selection procedures such as the AIC and SBIC provides a basis for choosing between TAR and M-TAR. A model with the lowest AIC and SBIC should be preferred (Acquah, 2012).

## 4. Results and Discussion

Findings show that prices are very unstable (coefficient of variation greater than 15 %) within the study period. The fluctuations calculated from the coefficient of variation show that the price of cassava varies by 51.5 % above or below its average value in the West Region.

Figure 3 below shows that, in general, cassava prices on the studied markets are on an upward trend, with the price of cassava on the Littoral remaining the highest at an average of 130.5 CFAF/kg, while the lowest price is observed on the West market with an average price of 64.9 CFAF/kg. A comparison of prices on the three markets from January 2000 to December 2012 shows that the price on the western market is characterized by little fluctuation, while the prices of manioc on the central and coastal markets are characterized by strong fluctuations. This irregularity could be explained by seasonality. From January 2012 to December 2022, a comparison of prices on the three markets shows that the price of cassava in the Littoral and Centre markets remains relatively constant, while the price in the West Region market is characterized by strong fluctuations. The implication is that the West Region remains the area where the supply of cassava is cheapest.

Below summarizes the calculation of coefficients of variation from January 2012 to December 2022 for cassava prices.

**Table 1: Coefficients of variation for cassava prices**

| *Region* | *Mean* | *Standard deviation* | *CV (%)* |
|---|---|---|---|
| West | 64.9 | 33.4 | 51.5 |
| Centre | 110.5 | 24.0 | 21.7 |
| Littoral | 130.5 | 22.0 | 16.9 |

*Source:* SNI/ Author (2022)

Generally, prices are very unstable (coefficient of variation greater than 15 %) over the study period. The fluctuations calculated from the coefficient of variation show that the price of cassava varies by almost 51.5 % above or below its average value in the West Region.

The price of cassava is therefore very unstable in the West Region. On the Central market, it fluctuates by almost 21.7 % above or below its average value. In the Littoral market, it fluctuates around its average value by almost 16.9 %.

The price of cassava is therefore less volatile in the Littoral region than in the other two regions.

**Table 2: Matrix of price correlation coefficients**

| *Correlation* | *Price_Centre* | *Price Littoral* | *Price_West* |
|---|---|---|---|
| Price_Centre | 1 | 0.88 | 0.88 |
| Price_Littoral | 0.88 | 1 | 0.75 |
| Price_West | 0.88 | 0.75 | 1 |

*Source:* SNI/ Author (2022)

From table 2, findings show that the price series in the Centre Region is strongly (r = 0.88) positively correlated with the price of the Littoral. In general, this shows that prices are relatively correlated in the study period.

## *4.1. Study of the seasonality of variables*

The Kruskal-Wallis test, applied to the three nominal price series, gave the following results: KW= 25.03 (P-Value= 0.9 %) for the cassava price series in the Centre and a KW= 9.28 (P-Value= 59.6%) statistic in the Littoral and finally a DW = 38.12 (p-value =0.007 %) statistic for the West series.

Thus, at the 10 % threshold, the price of cassava in the Littoral shows no seasonality, whereas the price of cassava in the Centre and West are seasonal. However, the cassava price series in the Centre and West Regions have been corrected for seasonal variations.

## *4.2. Study of the stationarity of variables*

In order to study cointegration, a necessary condition is that the variables must be integrated in the same order. This is why we devote this section to

**Table 3: Unit root test on the different variables**

| | *Level Tests* | | | *First Difference* | | |
|---|---|---|---|---|---|---|
| *Variables* | *ADF* | *PP* | *KPSS* | *ADF* | *PP* | *KPSS* |
| PRICE_CENTRE | -1.94 (0.94) | -1.94 (0.97) | 1.97 (0.46) | -1.94 (0) * | -1.94 (0) * | 0.08 (0.46) |
| PRICE_LITTORAL | -1.94 (0.98) | -1.94 (0.99) | | -1.94(0) * | -1.94(0) * | 0.25 (0.46) |
| PRICE_WEST | -1.94(0.54) | -1.94 (0.74) | | -1.94(0) * | -1.94(0) * | 0.04 (0.46) |

*Source:* Our calculations (2022)on Eviews 10.0

* indicates that the test allows us to conclude that the series is stationary.

The values in brackets represent the p-values of the test at the 5% threshold.

the study of the stationarity of the variables. In this work, the Philips-Perron (PP) Augmented Dickey and Fuller (ADF) unit root test and the Kwiatkowski-Phillips-Schmidt Shin (KPSS) stationarity test without trend or constant are performed on all the variables in the study.

After analyzing the stationarity of the variables, we are interested in studying a possible long-term relationship between prices in the different regions. The results of these tests are reported in Table 3. The study of the stationarity of the variables shows that all the variables are stationary in the first difference. Indeed, the two tests (ADF, PP, KPSS) lead to the conclusion that the price of cassava in the Littoral, Centre and West regions admit a unit root in level but are all stationary in first difference. Thus, they are all integrated of order 1 at the 5 % threshold. In conclusion, the variables are considered to be integrated of order 1.

## 4.3. Pairwise cointegration results

### 4.3.1. Engle & Granger's two-step test (1987)

- **Step 1 [**Long-term relationship].

A stationary linear combination of the variables is sought by estimating each of the following long-term relationships and the one with a stationary residual is selected.

Long-term relationships of the Granger cointegration test between the different regions.

- **Step 2 [**Test for stationarity of estimated residuals].

**Table 4: Results of the stationarity test of the estimation residual of the long-term relationship**

| | *Constant* | *Centre Region Price* | *Littoral Region price* | *West Region Price* | *ADF* |
|---|---|---|---|---|---|
| Model residual (1) | -0.89 (0) * | - | 1.14 (0) | - | -6.35 (-3.37) ** |
| Model residual (2) | 3.17 (0) * | - | - | 0.37(0) | -4.84 (-3.37) ** |
| Model residual (3) | 3.86 (0) * | - | - | 0.24(0) | -5.65 (-3.37) ** |

* indicates that the test leads to the conclusion that the series is stationary. The values in brackets represent the p-values of the test at the 5% threshold.** Value read from Mackinnon's (1993) table.
*Source:* Our calculations (2022)

These results show that the residual series of the long-term model is stationary. These two steps finally indicate that cassava prices are linearly cointegrated such that there is a restoring force tending to bring the Centre cassava price back to long-term equilibrium in response to variations in the Littoral cassava price.

There is therefore a linear long-term relationship between the different cassava price series. In particular, the price of cassava in the Littoral is explained by the price of cassava in the West Region in the long term.

Once the long-term relationship has been estimated, stationarity tests have been carried out on the residual. In this case the Dickey and Fuller (1979) table is no longer valid, the Mackinnon (1993) table is used. The results show that the residuals are stationary, so the variables are co-integrated.

### *4.3.2. The threshold cointegration test*

The estimation of a TAR model, from the residual from the above long-run relationship, yielded the following results:

TAR model of the threshold co-integration test (Enders and Siklos, 1998).

**Table 5: TAR model estimation with endogenous determination of the city pair threshold**

| *Centre and Littoral Regions* | *TAR* | *MTAR* |
|---|---|---|
| Threshold $\tau$ | -0.04 | -0.005 |
| $\rho_1$ | 0.83 (0) * | -0.16 (0) |
| $\rho_2$ | 0.48 | -0.56 |
| Tmax | 15.9 | -0.55 (0) * |
| $\Phi$ ($\rho_1 = \rho_2 = 0$) | 148.3 (0) * | 29.47 (0) * |
| *W* ($\rho_1 = \rho_2$) | 15.7 (0) * | 17.18 (0) * |
| *DW* | 2.03 | 2.05 |
| Number of delays | 1 | 1 |
| **Centre and West Regions** | | |
| Threshold $\tau$ | 0.06 | 0.03 |
| $\rho_1$ | 0.99 (0) * | -0.31 (0) |
| $\rho_2$ | 0.81 | -0.11 |
| Tmax | 21.4 | -3.17 |
| $\Phi$ ($\rho_1 = \rho_2 = 0$) | 394.8 (0) * | 15.7 (0) * |
| W ($\rho_1 = \rho_2$) | 7.5 (0) * | 7.15 (0) * |
| *DW* | 2.09 | 1.95 |
| Number of delays | 1 | 1 |
| **Littoral and West Regions** | | |
| Seuil $\tau$ | 0.08 | 0.001 |
| $\rho_1$ | 0.57 (0) * | -0.26 (0) |
| $\rho_2$ | 0.84 (0) | -0.18 (0) |
| Tmax | 19.53 | -3.45 |
| $\Phi$ ($\rho_1 = \rho_2 = 0$) | 218.4 (0) * | 16.8 (0) * |

| *Centre and Littoral Regions* | *TAR* | *MTAR* |
|---|---|---|
| $W(\rho_1 = \rho_2)$ | 9.9 (0) * | 1.23 (0.26) * |
| *DW* | 2.12 | 2.05 |
| Number of delays | 1 | 1 |

*Source:* Author's calculation (2022)

*Note:* * denotes that the coefficients are significant at the 5% level. Values in brackets denote the p-value associated with the coefficients.

Once the long-term relationship has been estimated, stationarity tests have been carried out on the residual. In this case the Dickey and Fuller (1979) table is no longer valid, the Mackinnon (1993) table is used. The results show that the residuals are stationary, so the variables are co-integrated.

## *4.4. Markets in the Centre and Littoral*

Overall, the long-run analysis shows that the changes made on the Littoral markets are fully transmitted to the Centre market. Indeed, the elasticity of the Centre price with respect to the Littoral price is greater than 1 for all relationships. A 1 % increase in Littoral prices in the long run leads to a 114 % increase in the price of cassava in the Centre. Elasticities greater than 1 indicate that Littoral prices are not fully transmitted to Centre prices. Once the long-term relationship was estimated, stationarity tests were carried out on the residual.

## *4.5. Markets in the Centre and West*

The long-run analysis shows that changes in the West markets are not fully transmitted to the Centre market. Indeed, the elasticity of the Centre price with respect to the West price is less than 1 for all relationships. A 1 % increase in West prices in the long run leads to a 37 % increase in the price of cassava in the Centre. Elasticities below 1 indicate that West prices are not fully transmitted to Centre prices.

## *4.6. Markets in the Littoral and West*

Table 5 shows that changes in the West Region market are not fully transmitted to the Littoral market. Indeed, the elasticity of the Littoral price with respect to the West Region price is less than 1 for all relationships. 1% increase in West Region ern prices in the long run leads to a 24% increase in the price of cassava in the Littoral Region. Elasticities below 1 indicate that West Region prices are not fully transmitted to Littoral prices

## 4.7. Seasonality tests

The summary statistics for cassava price series are presented in Table 6. The overall mean and standard deviation of cassava product yields do not show any clear results in terms of superiority of cassava price volatility between the Centre, Littoral and West markets.

**Table 6: Descriptive Statistics of some covariates**

| | *N* | *Minimum* | *Maximum* | *Mean* | *SD* |
|---|---|---|---|---|---|
| CENTRE | | | | | |
| rainfall_yde | 27 | 1206,30 | 1836,70 | 1444,88 | 141,57 |
| temp_yde | 27 | 23,90 | 26,53 | 25,39 | 0,76 |
| Yield_yde | 23 | 398,65 | 2236997,01 | 958615,60 | 808582,74 |
| inflation_yde | 23 | 79,32 | 106,85 | 93,08 | 8,49 |
| price_yde | 27 | 43,00 | 149,42 | 97,96 | 32,05 |
| LITTORAL | | | | | |
| rainfall_dla | 27 | 2813,90 | 4706,49 | 4056,13 | 524,15 |
| temp_dla | 27 | 27,00 | 28,30 | 27,60 | 0,35 |
| Yield_dla | 23 | 195,45 | 597229,35 | 257811,07 | 215132,22 |
| inflation_dla | 23 | 86,45 | 116,46 | 101,45 | 9,26 |
| price_dla | 27 | 72,20 | 164,15 | 118,82 | 27,81 |
| WEST | | | | | |
| rainfall_baf | 27 | 1313,70 | 1988,60 | 1807,01 | 143,90 |
| temp_baf | 27 | 19,30 | 24,03 | 22,03 | 1,31 |
| Yield_baf | 23 | 32,37 | 238073,02 | 103270,92 | 85682,52 |
| inflation_baf | 23 | 160,93 | 216,80 | 188,85 | 17,23 |
| price_baf | 27 | 1,00 | 136,79 | 53,76 | 41,74 |

*Source:* NIS, 2022

The results and the conclusion of seasonality tests are presented in table 3. We used two tests: the F-test and the Q2 parameter test. We use seasonally adjusted data for econometric models when the two tests have suggested the existence of seasonality. However, when the results have pointed out the evidence of a non-stable seasonality and lead to contradictory conclusions (When the F test suggests the presence of seasonality, but the Q2 parameter suggests the rejection of the hypothesis of seasonality), I use non-seasonally adjusted data.

## 4.8. Determinants of price volatility

From what appears in Table 7, we can see that the model is globally significant for modelling price volatility. The variables that explain this volatility are yield, inflation, interest, temperature and climate. The determinants of price volatility of cassava are presented in table 48 below. All the variables are significant and affect market efficiency in one way or the other, either positively or negatively. To begin with,

### *4.8.1. Yield*

The coefficient on the yield variable is positive and significant at the 5 % level. This result indicates that a seller's returns increase the probability that cassava prices are volatile at the 5% level. Marginal effects inform us that sellers' returns contribute 25 % to the probability that cassava prices are volatile.

### *4.8.2. Interest*

The coefficient of the variable Interest is negative and significant at the 5 % level. This result indicates that interest reduces the probability that cassava prices are volatile. The marginal effects inform us that interest contributes negatively to 57 % of the probability of price volatility.

### *4.8.3. Climate*

The coefficient on the Climate variable is positive and significant at the 5 % level. This result indicates that climate change increases the probability that cassava prices will be volatile. The marginal effects inform us that the stock variation contributes to 17% of the probability of cassava price volatility.

**Table 7: Drivers of price volatility**

| *Variables* | ***Coefficients*** | ***p value*** | *dy/dx* |
|---|---|---|---|
| Yield | 0.25** | 0.009 | 0.25 |
| Inflation | -0.076 | 0.259 | -0.076 |
| Interest | 0.082** | 0.000 | 0.055 |
| Temperature | -0.68 | 0.311 | -0.685 |
| Climate | 0.17 | 0.000 | 0.171 |
| Constant | 0.265* | 0.070 | 0.000 |
| Sigma | 0.115* | 0.005 | |
| Prob>chi2 | 0.0000 | | |
| LR chi2 (5) | 44.05 | | |

*Source:* Author's computation based on survey data, 2022; Notes: ***, **, * represent significance at the 1%, 5% and 10% respectively

From the analysis of these results, we observe that cassava prices in the Centre, West and Littoral regions over the period 1994-2022.

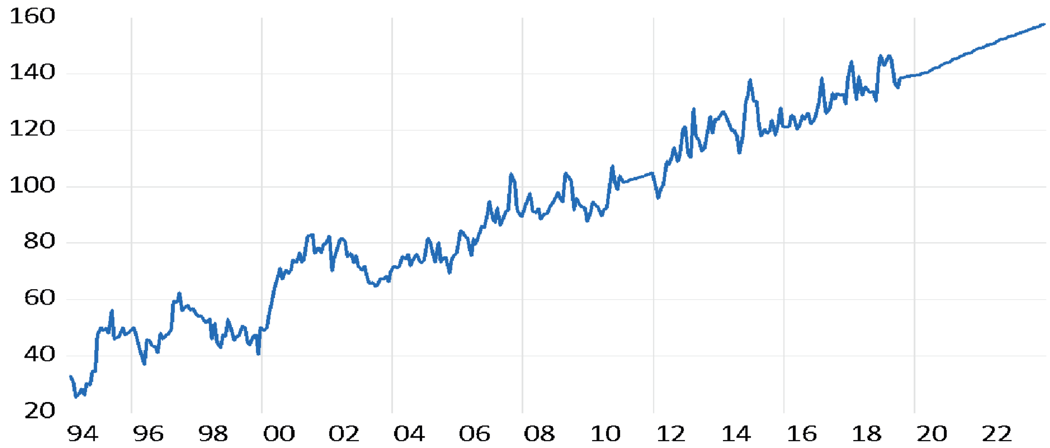


**Figure 4: Trend Total prices**

*Source:* NSI/ Author, 2022

Figure 4 exhibits a trend in yearly total prices of cassava. If there is growth, it will be evident that the highest cassava price was relatively at the beginning and end of the year.

## 4.9. *Time Series Model for Food Price Volatility*

To analyze the determinants of food price volatility in Cameroon, we have applied time series econometric models as suggested earlier. Then, we have successfully estimated the ARMA and GARCH model. First, the results of standard unit root tests without and with structural break (ADF and PP) suggest that all the return price series are stationary (see table 1.8 in the appendix). In addition, the Box and Jenkins approach has been used to determine the appropriate ARMA structure of each return price series. Also, for each ARMA model, a Breusch-Godfrey Serial Correlation LM Test has been applied and an ARCH LM test has been used to test for ARCH effect.

**Table 8: The Stationarity - Augmented Dickey-Fuller Test**

| *Variable* | *Dickey-Fuller Augmented Test* | |
|---|---|---|
| | *Level test* | *First Difference Test* |
| **Total Price** | 1.88 (0.9859) | -16.65264 (0.0000) |

*Source:* NSI/ Author, 2022

Table 8 shows the result of the stationarity test using the ADF method.

The result indicates that none of the series is stationary. Consequently, the levels of the series will generate spurious results if used for estimation. The results of the test indicate that the real price series for cassava globally are seasonal (indicating the effect of the period) at a significance level of 5%. Consequently, the levels of the series will generate spurious results if used for estimation.

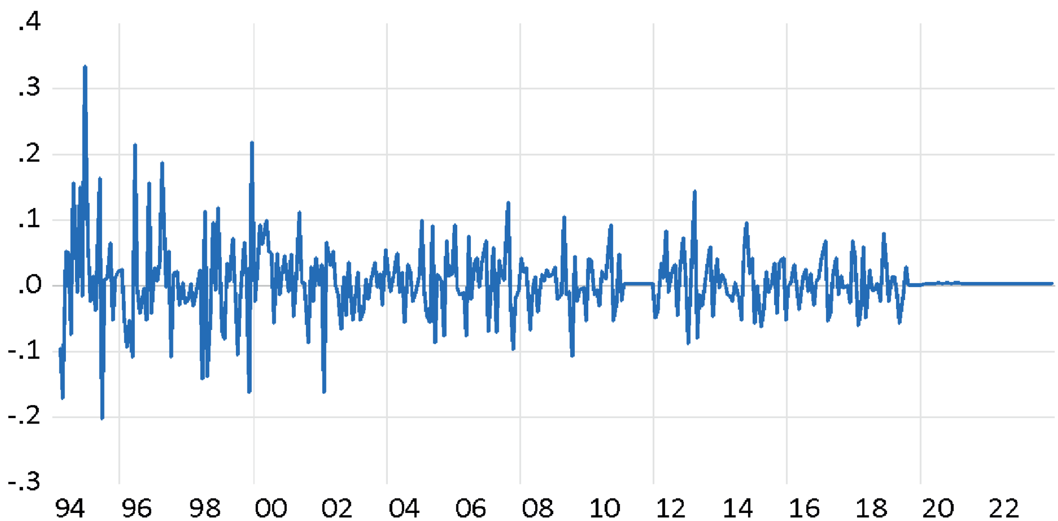


**Figure 5: Returns Total Price**

*Source:* NSI/ Author, 2022

Graph shows the Variance is non-constant. The result indicates that the total price of figure 2 exhibits a positive and negative trend and shows that the cassava price in the three regions are volatile. In addition, visual inspection of NSI returns over the period 1994-2022, shown in Figure 2, reveals that changes in volatility over time tend to cluster financial returns, which is also an indicator of long-term memory. In other words, large changes tend to be followed by other large changes, and vice versa, small changes are also followed by other small changes.

### *4.9.1. Case of the Centre*

Table 9 shows the Different ARMA model estimated to determine a parsimonious result

**Table 9: Different ARMA model estimated - Centre region**

Estimation of AR(1) model.

| *Variable* | *Coefficient* | *T-statistic* | *P-value* |
|---|---|---|---|
| **Constante** | 0.004051 | 1.629179 | 0.1042 |
| **AR(1)** | 0.296276 | 1.320480 | 0.1875 |
| **MA(1)** | -0.453142 | -2.165231 | 0.0310 |
| **SIGMASQ** | 0.002920 | 30.57256 | 0.0000 |
| **t-value** | 3.183072 (0.024023) | | |
| **R-squared** | 0.026267 | | |
| **AIC** | -2.976001 | | |

*Source:* NSI/ Author, 2022

Estimation of AR(2) model.

| *Variable* | *Coefficient* | *T-statistic* | *P-value* |
|---|---|---|---|
| **Constante** | 0.004058 | 1.622644 | 0.1056 |
| **AR(1)** | -0.153269 | -3.956025 | 0.0001 |
| **MA(2)** | -0.094088 | -2.550553 | 0.0112 |
| **SIGMASQ** | 0.002917 | 31.43821 | 0.0000 |
| **t-value** | 3.302474 (0. .020484) | | |
| **R-squared** | 0.026267 | | |
| **AIC** | -2.976975 | | |

Estimation of AR(3) model.

| *Variable* | *Coefficient* | *T-statistic* | *P-value* |
|---|---|---|---|
| **Constante** | 0.004035 | 1.545840 | 0.1230 |
| **AR(3)** | -0.009256 | -0.236241 | 0.8134 |
| **MA(1)** | -0.164158 | -4.569258 | 0.0000 |
| **SIGMASQ** | 0.002929 | 31.30939 | 0.0000 |
| **t-value** | 2.773586 (0.041377) | | |
| **R-squared** | 0.022965 | | |
| **AIC** | -2.972632 | | |

*Source:* NSI/ Author, 2022

We choose ARMA(1, 2) since both ar(1) and ma(2) coefficients are significant

Table 10 represents the Augmented Dickey Fuller (ADF) test to examine the unit roots in return series. The main result based on this test is that; ADF is statistically significant at 1% level. This indicates to reject null hypothesis and accept that the returns are stationery; hence, It means reverting. That all confirms the non-existence of autocorrelation.

**Table 10: Estimated ARCH/GARCH Model**

| *Variable* | *Coefficient* | *T-statistic* | *P-value* |
|---|---|---|---|
| **C** | 0.002408 | 3.763262 | 0.0002 |
| **Residu^2(-1)** | 0.086584 | 1.634157 | 0.1031 |
| **Residu^2(-2)** | 0.074639 | 1.408578 | 0.1598 |
| **t-value** | 2.564759 (0.078371) | | |
| **R-squared** | 0.014323 | | |
| **AIC** | -6.100315 | | |

*Source:* NSI/ Author, 2022

There is no ARCH effect since the residual term and the F-test are not significant. Hence, the overall result does not require volatility modeling since there is no volatility at the end of the forecasted period.

## *4.9.2. The case of the Littoral*

Table 11 shows the Different ARMA model estimated to determine a parsimonious result

**Table 11: Different ARMA model estimated_ Littoral region**

Estimation of AR(1) model.

| *Variable* | *Coefficient* | *T-statistic* | ***P-value*** |
|---|---|---|---|
| **Constante** | 0.003568 | 1.308532 | 0.1915 |
| **AR(1)** | 0.429074 | 4.274186 | 0.0000 |
| **MA(1)** | -0.681973 | -8.140619 | 0.0000 |
| **SIGMASQ** | 0.007508 | 31.58446 | 0.0000 |
| **t-value** | 9.050770 (0.000009) | | |
| **R-squared** | 0.071237 | | |
| **AIC** | -1.987797 | | |

*Source:* NSI/ Author, 2022

Estimation of AR(2) model.

| *Variable* | *Coefficient* | *T-statistic* | *P-value* |
|---|---|---|---|
| **Constante** | 0.003449 | 1.056366 | 0.2915 |
| **AR(1)** | -0.270578 | -8.542321 | 0.0000 |
| **MA(2)** | -0.149229 | -3.243118 | 0.0013 |
| **SIGMASQ** | 0.007529 | 28.34785 | 0.0000 |
| **t-value** | 9.050770 (0.000009) | | |
| **R-squared** | 0.068718 | | |
| **AIC** | -2.028551 | | |

*Source:* NSI/ Author, 2022

Table 12 shows the Series is stationary and the result of the stationarity test using ADF method. The result indicates that none of the series is stationary. We choose ARMA(1 1) since both ar(1) and ma(1) coefficient are more significant

Both AR (1) is close to significance and MA(1) coefficient is significant which represent the Mean Equation and the ARCH i.e RESID(-1)^2 and GARCH coefficients which represent the VARIANCE EQUATION are significant as well. RESID(-1)^2 + GARCH = 0.747 approximately 0.75 which is closer to 1, implying that the persistence of volatility is high. The result shows that cassava price is volatile. The summation of the coefficients of the ARCH (0.145997) and GARCH (0.595997) is very close to one, and this shows that the price of cassava continues to be volatile and it is in line with a priori expectation. Observations show that inflations in Cameroon fluctuate and affect household spending patterns. F test shows no Heteroscedasticity implying no ARCH effect again. Hence the model is robust.

There are no more lags for the Autocorrelation and Partial correlation functions and the probability values are greater than 0.05. Again the model is good. So the GARCH (1 1) model satisfies the model specification

### *4.9.3. The case of the West*

Table 12 shows the Different ARMA model estimated to determine a parsimonious result

**Table 12: Different ARMA model estimated**

Estimation of AR(1) model.

| *Variable* | *Coefficient* | *T-statistic* | *P-value* |
|---|---|---|---|
| Constante | 0.013358 | 3.215642 | 0.0014 |
| **AR(1)** | 0.449879 | 1.762539 | 0.0788 |
| **MA(1)** | -0.527957 | -2.150203 | 0.0322 |
| **SIGMASQ** | 0.006837 | 36.56307 | 0.0000 |
| **t-value** | 0.861104 (0.0461437) | | |
| **R-squared** | 0.007245 | | |
| **AIC** | -2.125225 | | |

*Source:* NSI/ Author

Estimation of AR (2) model.

| *Variable* | *Coefficient* | *T-statistic* | *P-value* |
|---|---|---|---|
| **Constante** | 0.013259 | 3.164055 | 0.0017 |
| **AR(2)** | -0.629740 | -6.739161 | 0.0000 |
| **MA(2)** | 0.447714 | 4.113170 | 0.0000 |
| **SIGMASQ** | 0.006606 | 34.23517 | 0.0000 |

| | | | |
|---|---|---|---|
| **t-value** | 5.016618 (0.002034) | | |
| **R-squared** | 0.040780 | | |
| **AIC** | -2.125225 | | |

*Source:* NSI/ Author, 2022

We choose ARMA(2 2) since both ar(2) and ma(2) coefficient are significant

We choose ARCH(2) because the residual is significant and the F-test is significant as well.

**Table 13: GARCH result in the volatility of cassava**

| *Variable* | *Coefficient* | *T-statistic* | *P-value* |
|---|---|---|---|
| **Constante** | 0.011408 | 1.201368 | 0.2296 |
| **AR(1)** | -0.476581 | -5.259695 | 0.0000 |
| **MA(5)** | 0.367306 | 3.121450 | 0.0018 |
| VARIANCE EQUATION | | | |
| **Constante** | 0.003655 | 1.435872 | 0.1510 |
| **Residu (-1)^2** | 0.150000 | 1.237744 | 0.2158 |
| **GARCH(-1)** | 0.600000 | 2.253127 | 0.0243 |
| **R-squared** | 0.019909 | | |
| **AIC** | -2.301007 | | |

*Source:* NSI/ Author, 2022

The table above presents the results of the heteroscedasticity test of the residuals. The analysis of this table shows that the residuals are homoscedastic (P=0.0000).

RESID(-1)$^{\wedge 2}$ + GARCH = 0.747 approximately 0.75 which is closer to 1, implying that the persistence of volatility is high. The GARCH(1,1) model as modeled is significant overall. There is therefore conditional heteroscedasticity in the error term. The Chi2 distribution and the critical probability associated with this distribution of the GARCH(1,1) regression show that the model as specified is globally significant at the 5% threshold for the price of cassava as indicated in Table 14 above.

Both AR(2) and MA(2) coefficients which represent the Mean Equation are significant only in ARCH(1 2) i.e RESID(-1)$^{\wedge 2}$ and RESID(-2)$^{\wedge 2}$ coefficients which represent the variance equation are significant as well.

RESID(-1)$^{\wedge 2}$ + RESID(-2)$^{\wedge 2}$ = 0.2 which is not closer to 1, implying that the persistence of volatility is very low. RESID(-1)$^{\wedge 2}$ + GARCH = 0.2, is very close to one, and this shows that the average price of the selected major food items will continue to be high and will continue to be volatile. The result shows that cassava price is volatile. The summation of the coefficients of the ARCH

(0.150000) and GARCH (0.050000) is very close to one, and this shows that the price of cassava continues to be volatile and it is in line with a priori expectation. Observations show that inflations in Cameroon fluctuate and affect household spending patterns.

F test shows no Heteroscedasticity implying no ARCH effect again. Hence the model is robust.

The table above presents the results of the heteroscedasticity test of the residuals. The analysis of this table shows that the residuals are homoscedastic (P=0.0000).

## 5. Discussion

The results of the Augmented Dickey-Fuller test for cassava prices are individually significant at the 5 % level. The model estimation process consisted of two steps: a stationary test and the determination of the ARCH model. Stationary tests were used to assess trends (Erkekoglu, Garang and Deng, 2020; Sahinli, 2020). Data can be stationary if the process does not change over time. The Augmented Dickey-Fuller (ADF) test was used to perform the stationary test. The ADF test was used to determine whether the data analyzed contained a unit root. If the p-value was > 0.05, then H0 was accepted and the cassava price data were not stationary. However, if the p-value was < 0.05, H0 was rejected and the cassava price data were stationary. The result of the ARCH/GARCH analysis indicated that the persistence of volatility is greater in cassava prices. he model used to detect heteroskedasticity can be determined by examining the significance of the probability values of the F-stat and chi-squared at the 5 % significance level (Das, Paul, Bhar and Paul, 2020; Deb, 2021; Lakshmanasamy, 2021; Lestar *et al.*, 2022). The Arch/Garch result also implies that higher cassava price volatility could adversely affect households by causing hunger or severe food insecurity, leading to malnutrition and riots.

Specifically, in the West region, the conditional variance coefficient is positive and individually significant at 5 %. This indicates that the F-test does not show heteroskedasticity, which means that there is no ARCH effect. This is indicated by the F-statistic and chi-square probability values of 0.0000 < 0.05. The model is therefore analyzed in more detail using ARCH-GARCH analysis (Jordaan *et al.,* 2007; Manogna & Mishra, 2020). The results show the heteroscedasticity test for the residuals; the sum of the ARCH and GARCH effects (0.997) indicates that cassava prices are highly volatile.

In the Littoral region, the F-test shows no heteroscedasticity, which means that there is no ARCH effect. The model is therefore robust. There are no more lags in the autocorrelation and partial correlation functions, and the probability values are greater than 0.05. The GARCH (1 1) model therefore satisfies the model specification. The value of the ARCH coefficient illustrates the high volatility of manioc prices. The closer the value of the ARCH coefficient (1.0) is to zero, the lower the volatility (Monk *et al*., 2010; Thiyagarajan *et al*., 2015). The estimated model yielded an ARCH coefficient of 0.277477, implying that the volatility of cassava in the coastal region from 1994 to 2004 is relatively low and close to zero. Volatility is a measure of price fluctuations or expected price movements over time (Barbaglia *et al*., 2020; Manogna and Mishra, 2020; Thiyagarajan *et al*., 2015; Lestar *et al*., 2022). Volatility also refers to unexpected price fluctuations, but this has yet to be determined. Some measures of volatility and risk assessment can be based on deviation, standard deviation and coefficient of variation.

In the Centre region, the conditional variance coefficient is positive and individually significant at 5 %. This indicates that there is no ARCH effect, as the residual term and the F-test are not significant. The constant term is insignificant. The coefficient on the first lagged value of the price of cassava is significant at 5 %. Thus, the price of cassava today is determined by the price of cassava in the immediate past. The significance of the ARCH and GARCH terms indicates that the volatility of prices in a given month depends on the volatility of prices in the previous month and that the variance of the current price depends on the variances of past prices. The coefficients imply that when price peaks occur, the process is very slow to reverse. The volatility of cassava prices can be measured using the conditional deviation norm, which was the root of ARCH-GARCH (1.0). The price of cassava in the Centre Region was not very volatile between 2012 and 2020. However, in certain months of 2008 and 2012, relatively large fluctuations occurred several times in January, June and October. The high volatility of cassava prices between 2008 and 2014 was due to the rise in commodity prices and the global financial crisis, which generally made sellers reluctant to unload their produce due to the risk of damage and high loss rates.

The findings of the model show that inflation and climate have positive and significant effects on the price of cassava. This means that a percentage change in inflation is expected to increase the price of cassava by 0.79 % and a 1 % increase in the exchange rate is expected to increase cassava price by 1.02 %. This calls for effective management of these macroeconomic variables to provide a continuous stable environment against price fluctuation. Moreover, variables such as yield and temperature have positive relationship with the price of cassava while interest rate and rainfall have negative relationship with cassava price though they are not significant.

The result is consistent with an empirical work by Gilbert (1989) which indicated that inflation level and its variability are major factors that influence food price volatility and can greatly affect the investors including farmers. This assertion was also stated by the IMF (2008) which also showed that fluctuations in inflation and exchange rate are condiments for output price volatility.

The positive relationship between the price of cassava and the quantity supplied (cassava yield) is consistent with the economic theory which states a positive relationship between the price of a commodity and its supply. This may explain why high prices persisted in Cameroon even after the 2008/9 food price crisis. Indeed, the volatility of cassava prices is a problem in Cameroon and several other countries (Devi et al., 2015; Kane *et al.*, 2018). The high volatility of cassava prices requires government intervention to stabilize them (Kane *et al*, 2018). This can serve as a reference for the government to develop policies to stabilize cassava prices.

## 6. Conclusion and Recomendations

The results highlight the following main points concerning price fluctuations for the cassava studied. Firstly, they confirm that cassava prices are more unstable than those of their presumed imported substitutes, which are storable and/or processed products. Secondly, a multiplicity of factors determines price fluctuations, such as inflation, interest, temperature and climate. Flows between regions, and probably the associated cropping systems that predominate in agroforestry, help to mitigate the impact of climatic hazards on consumer prices. Furthermore, the aim of reducing the uncertainties of domestic food markets could lead to renewed investment in local food chains, whose competitiveness would contribute to development mechanisms (poverty reduction, job creation).

By these studies finding, the following recommendations were made:

1. Marketers should organize themselves into cooperatives to enable them reap the benefits of economies of scale in areas of product transportation and storage. This would also help them benefit from credit facilities from agricultural and commercial banks and other micro credit financial institutions;
2. Means of transport should also be put in place thanks to the efforts of cooperatives to link farms to the market in order to reduce marketing costs and increase profits for traders.

3. There should also be the erection of market stalls, stores, and reduction in market taxes so as to improve the marketing of cassava in the study area.

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