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See table of contents

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Article abstract

In this paper, we have investigated the extent and the speed of adjustment of six domestic markets of imported rice and the local market of processed rice in Togo to rice prices change on the global market and how the local market of paddy and the imported rice markets respond respectively to prices change in the processed rice and on the central market of imported rice Lomé and test for asymmetry in the adjustment process using both standard and threshold cointegration tests. Symmetric and asymmetric error correction models with respect to the linear and threshold cointegration relationships between markets pairings are estimated to investigate short-run prices dynamics.

Results indicate that prices for the global to local markets pairings are cointegrated with relatively low price transmission elasticities. Prices on the imported rice markets in Togo are also cointegrated (when Lomé is considered as the central market). Threshold cointegration tests reveal that in the long-run, the local market of paddy adjusts asymmetrically to prices change in the processed rice and there is asymmetric adjustment of domestic markets of Cinkassé and Lomé to prices change on the global market. Except for Amégnran market, the four other domestic markets of imported rice adjust also asymmetrically to rice prices change on the central market of Lomé. In the short-run, there is asymmetric adjustment only between the global market and the imported rice markets of Lomé and Cinkassé. Among imported rice prices dynamics in Togo, only Cinkassé market adjust asymmetrically to prices change on the central market of Lomé. The results imply that oligopolistic middlemen in rice marketing in Togo are more sensitive and react quickly when rice prices change on the global market tends to squeeze their margins than changes that stretch them.

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SPATIAL PRICE TRANSMISSION AND ASYMMETRIC ADJUSTMENT: THE CASE OF LOCAL AND IMPORTED RICE IN TOGO*

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RÉSUMÉ – Dans cet article, nous avons déterminé le degré et la vitesse d'ajustement de six marchés intérieurs du riz importé et du marché local du riz transformé au Togo aux changements de prix du riz sur le marché mondial et la façon dont le marché local du riz paddy et les marchés locaux du riz importé réagissent respectivement aux changements de prix sur le marché local du riz transformé et le marché central du riz importé de Lomé et nous avons réalisé des tests d'asymétrie dans le processus d'ajustement en utilisant à la fois des tests de cointégration standard et à seuils. Des modèles à correction d'erreurs symétriques et asymétriques conformément aux relations de cointégration linéaire et à seuils entre les paires de marchés sont estimés pour étudier la dynamique d'ajustement des prix à court terme.

Les résultats indiquent que les paires de prix entre le marché mondial et les marchés intérieurs sont cointégrés avec des élasticités de transmission relativement faibles. Les prix sur les marchés du riz importé au Togo sont également cointégrés (lorsque Lomé est considérée comme le marché central). Les tests de cointégration à seuils révèlent qu'à long terme, le marché local du riz paddy s'ajuste de manière asymétrique aux changements de prix du riz transformé et que les marchés intérieurs de Cinkassé et de Lomé s'ajustent de manière asymétrique aux changements de prix sur le marché mondial. À l'exception du marché d'Amégnran, les quatre autres marchés intérieurs du riz importé s'ajustent également de manière asymétrique à l'évolution des prix du riz sur le marché central de Lomé. À court terme, il n'y a d'ajustement asymétrique qu'entre le marché mondial et les marchés du riz importé de Lomé et de Cinkassé. Parmi les dynamiques des prix du riz importé au Togo, seul le marché de Cinkassé s'ajuste de manière asymétrique aux changements de prix sur le marché central de Lomé. Il en résulte que les intermédiaires oligopolistiques dans la commercialisation du riz au Togo sont plus sensibles et réagissent plus rapidement lorsque

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les changements de prix du riz sur le marché mondial tendent à comprimer leurs marges que lorsque ces changements de prix du riz les étendent.

ABSTRACT – In this paper, we have investigated the extent and the speed of adjustment of six domestic markets of imported rice and the local market of processed rice in Togo to rice prices change on the global market and how the local market of paddy and the imported rice markets respond respectively to prices change in the processed rice and on the central market of imported rice Lomé and test for asymmetry in the adjustment process using both standard and threshold cointegration tests. Symmetric and asymmetric error correction models with respect to the linear and threshold cointegration relationships between markets pairings are estimated to investigate short-run prices dynamics.

Results indicate that prices for the global to local markets pairings are cointegrated with relatively low price transmission elasticities. Prices on the imported rice markets in Togo are also cointegrated (when Lomé is considered as the central market). Threshold cointegration tests reveal that in the long-run, the local market of paddy adjusts asymmetrically to prices change in the processed rice and there is asymmetric adjustment of domestic markets of Cinkassé and Lomé to prices change on the global market. Except for Amégnran market, the four other domestic markets of imported rice adjust also asymmetrically to rice prices change on the central market of Lomé. In the short-run, there is asymmetric adjustment only between the global market and the imported rice markets of Lomé and Cinkassé. Among imported rice prices dynamics in Togo, only Cinkassé market adjust asymmetrically to prices change on the central market of Lomé. The results imply that oligopolistic middlemen in rice marketing in Togo are more sensitive and react quickly when rice prices change on the global market tends to squeeze their margins than changes that stretch them.

INTRODUCTION

The analysis of price transmission has been widely investigated in the literature of agricultural economics. This is because price transmission between geographically separated markets or along the marketing chain drives resources allocation, allows international specialization and so has welfare implications (see Amikuzuno and Ogundari, 2012; Bakucs *et al.*, 2014; Fackler and Goodwin, 2001; Meyer and von Cramon-Taubadel, 2004). More importantly, asymmetric price transmission analysis is of considerable importance for public policy as asymmetric price transmission alters welfare redistribution with respect to prices change and is associated with welfare losses when it stems from market failure (Meyer and von Cramon-Taubadel, 2004; Wondemu, 2015). Despite the widespreadness of these studies, they are still relevant. Indeed, the vulnerability of households in developing countries to food prices hike during the recent 2007-2008 global food crisis have shown the necessity to better understand the extent to which the global food prices shocks are transmitted to local markets of developing countries to enlighten policy makers. In effect, if these patterns are not well understood, especially in developing countries, it could constitute a great source of food insecurity (Barrett and Maxwell, 2006). Unfortunately, Dillon and Barrett (2016) stated that the lament of Deaton (Deaton, 1999) that the understanding of commodity prices behavior and the ability to forecast them remains seriously inadequate and without this understanding it is difficult to construct good policy is still a concern

today. On the other side, empirical studies have shown that the global to local price transmission patterns vary considerably between developed and developing countries, among developing countries and across-commodity and probably over time and are context specific (Abbott, 2009; Baltzer, 2013; DFID, 2014; Li and Huh, 2012; Minot, 2010). Moreover, the major part of these studies suffers from methodological limitations assuming instantaneous pass-through and so ignoring threshold effects. In this wise, there is a need for reliable country-case global to local price transmission analyses to guide country level evidence-based economic policy in ones attempt to avoid "one size fits all" policy recommendation.

Nonetheless, since the recent 2007-2008 global food crisis, there has been a renew of global to local price transmission analyses in West Africa dealing with asymmetries in their analyses with a focus on cereals especially rice as most of countries in the region are largely dependent on staples imports. Badolo (2012) has investigated the relationship between the imported rice prices on two markets of Burkina Faso (Sankaryaré and Dori markets) and the international rice prices using threshold cointegration. The author found that the imported rice prices on these markets are integrated with rice prices on the international market and prices increase on the international market are transmitted more rapidly to theses domestic markets than decreases. Still in Burkina Faso, Otoo (2012) has extended the analysis of Badolo (2012) to the local rice, maize and sorghum and found that domestic consumer prices are integrated with the world market prices. Threshold and asymmetric error correction models revealed as in the case of imported rice that consumer prices of maize, sorghum and local rice respond rapidly to negative deviations than positive deviations. So, maize, sorghum and rice price transmission in Burkina Faso is found to be asymmetric. This highlight inefficiencies in cereals marketing in Burkina Foso.

Fiamohe *et al.* (2015) have also investigated the integration of some West African rice markets to the global rice market using rice prices in Cotonou for Benin, Bamako for Mali and Dakar for Senegal. The authors found that rice markets in Benin and Mali adjust asymmetrically to the global rice market prices shocks and suggest short-run dynamic inefficiencies. However, the adjustment of Senegal rice market is linear suggesting greater integration to the world market. In Togo where households are extremely vulnerable to food prices shocks (Dia Kamgnia, 2011), Tchalim (2015) has investigated the relationship between rice prices on the international and domestic markets. The author found a high global to local price transmission elasticity and asymmetry in the long and short-run adjustment of domestic markets. While this study is informative, it does not allow understanding how domestically separated markets of local and imported rice are related to the global market. Moreover, it does not bring insight on the relationship between domestically separated markets of imported rice in Togo. Our study goes beyond Tchalim's analysis not only by taking into account various domestic markets in the global to local price transmission analysis but also by investigating price transmission analysis between domestically separated markets of imported rice in Togo. Our study extends the analysis of Yovo (2017) who has

investigated maize price transmission in Togo (between Lomé and nine (9) rural markets and found asymmetry in the adjustment process and so contribute to the understanding of the performance of domestic cereals markets in Togo. This is relevant since the analysis of rice markets in Togo have revealed different market conditions across regions (Adjognon, 2012) and the way prices signals are transmitted to farmers and consumers located at different places is determinant for food security.

The aim of this paper is to determine the extent and the speed of adjustment of domestic markets of the local and imported rice to rice prices chocks on the world market and how the local market of paddy and the imported rice markets respond respectively to changes in the processed rice and Lomé market prices and test for asymmetry in the adjustments processes. We have made use of both standard and threshold cointegration tests and estimated symmetric and asymmetric error correction models with respect to the standard and threshold cointegration relationships between prices pairs using monthly retail price of imported rice in Togo collected on six domestic markets, average monthly retail prices of paddy and processed rice and monthly prices of Thai's rice exports to the world market. The results of Engle and Granger (1987) and Johansen (1988) cointegration tests show that rice prices on the world and on domestic markets are cointegrated and the long-run price transmission elasticities are overall relatively low. Prices for the imported rice markets pairing with the central market of Lomé are also cointegrated. The results of threshold cointegration reveal an asymmetric adjustment of paddy prices to changes in the processed rice prices and asymmetric adjustment of domestic markets of imported rice of Cinkassé and Lomé to prices change on the global market in the long-run. Four domestic markets of imported rice namely Cinkassé, Korbongou, Kara and Anié adjust also asymmetrically to rice prices change on the central market of Lomé. In the short-run, there is asymmetric adjustment only for the dynamics between the global and local markets pairings Cinkassé-World and Lome-World and between domestic imported rice markets pair Cinkassé-Lomé. The remainder of the paper is organized as follows. Section 1 introduces the rice market in Togo, section 2 presents the materials and methods, section 3 presents and discusses results from the empirical analyses and the last section concludes.

1. THE RICE MARKET IN TOGO

Rice, maize and sorghum are the most grown and consumed cereals in Togo. But while the country is more than self-sufficient in maize and sorghum, it relies heavily on the world market to adjust for its deficits in rice despite the great potential to achieve self-sufficiency. Studies on rice consumer preferences in Togo have shown that the imported rice is preferred to the local rice (see Tchabletienne *et al.*, 2010). Mostly consumed in urban areas (but local rice is predominantly consumed in rural areas), rice has become part of households' daily food consumption in Togo. With an average annual per capita consumption of 28 Kg, rice is ranked

third behind maize and sorghum and account for 10% of the total dietary energy supply (FAO, 2011). Rice is grown in all regions in Togo but it is predominantly produced in the Plateaux, Kara and Savanna regions. According to the Africa Rice Survey initiated in 2010, the imported rice dominates weekly sales in all regions except for the Savanna region where locally produced rice dominates the quantities of rice traded weekly. Given the importance of rice in food security in Togo and rice prices hike pressure on balance of payments, the objective of the state authorities is to reduce rice imports which cost on average 4 billions of francs CFA per year by boosting local production. Hence, since the recent 2007-2008 global food crisis, the government has renewed its support to rice farmers who are predominantly engaged in small-scale farming subject to rainfall variability through subsidies in seed and fertilizer purchases and credit facilities. The government intervenes also in rice marketing in Togo to incite rice farmers through the national agency for food security (ANSAT) which is in charge of agricultural food commodity prices regulation.

Rice marketing in Togo depicts some characteristics that are worth mentioning. Rice or cereals marketing in general is characterized by high transaction costs due in part to inadequate infrastructures (Koffi-Tessio *et al.*, 2008). Rice farmers who are at the beginning of the marketing chain sell individually their paddy to private processors or to wholesalers often on the basis of prior informal credits. A survey on a sample of 353 rice farmers in the South of Togo revealed that, 90% of these farmers sell individually their production and 73% of them sell it in the form of paddy (Hodjo and Acharya, 2015). Another survey on a sample of 60 wholesalers of local rice at Kovié showed that, 25% of wholesalers grant credits to rice farmers (Koffi Emmanuel, 2010). This could indicate a weak negotiating power of rice farmers in paddy prices formation in Togo. Using the 2010 Africa Rice Center's consumer preferences survey, Adjognon (2012) has shown that, the four biggest rice traders in Togo have control on more than 50% of the total volume of rice traded weekly indicating an oligopolistic market structure. Imported rice markets are highly concentrated than the local rice with the highest concentration ratio in the Maritimes region (82.11%). The average marketing margin is 35% with the highest ones in the Savanna (46.97%) and Maritimes (40.73%) regions.

2. MATERIALS AND METHODS

2.1 *Data*

Data used in this paper are from the FAO's Global Information and Early Warning System (GIEWS) database which contains information on monthly retail prices of imported rice in Togo collected on six domestic markets namely Cinkassé (a urban market in the North-West of the country), Korbongou (a rural market in the North-East of the country) and Kara (a urban market in the Center-North of the country), Anié (a urban market in the Center-South of the country), Amégnran (a rural market in the South-West of the country) and Lomé (the largest urban market along the coast) on the period January 2001 to December 2015. We

have also made use of monthly retail prices of Thai' rice exports to the world market spanning from January 2000 to December 2015 as Thailand is the main supplier of rice to West African countries (Fiamohe *et al.*, 2015). These data are completed by average monthly retail prices of local rice from the board of agricultural statistics, information and documentation in Togo (DSID) available on the period January 2000 to December 2014. All of these series are in FCFA per kilogram. Nominal prices are used to avoid altering their time series properties (see Hanawa-Peterson and Tomek, 2000). Thai rice exports are converted in FCFA using the nominal exchange rates from the USDA (2016).

2.2 *Rice prices trends and descriptive statistics*

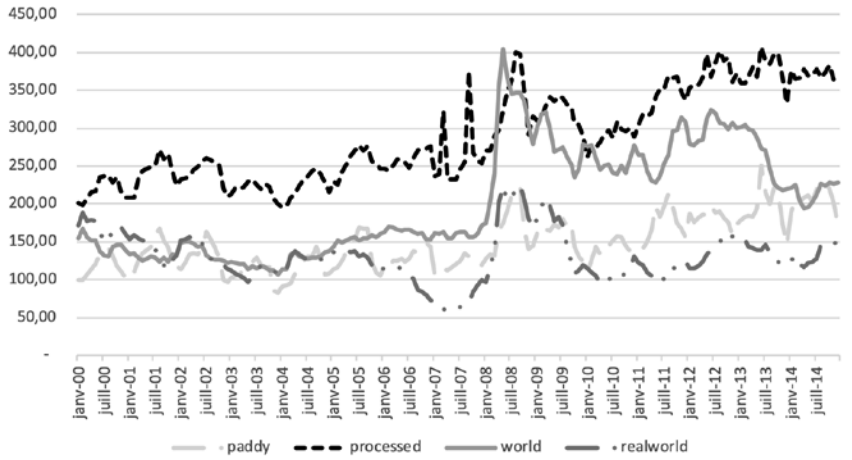
Rice prices trends show that, there is a close relationship between prices on domestic markets of local and imported rice and prices on the world market (see figure 1 and 2). Sharp increases in prices are observed on domestic markets of local and imported rice during the 2007-2008 global food crisis and have remained high afterwards. Focusing on the imported rice, prices on domestic markets are well above those on the world market due to imports transaction costs. Prior to the recent global food crisis, prices are relatively low on the market of Lomé from which almost all of the imported rice is distributed to other domestic markets of imported rice in Togo due to transport cost. Nonetheless, set aside transport costs, price differences between domestic markets of imported rice could be explained by local market conditions as the imported rice prices on Kara and Amégnran markets were well above prices on Cinkassé and Korbongou markets located farther to Lomé market. During the global food crisis, imported rice prices have responded after few months to prices hike on the global market but Amégnran market has responded latterly. Afterwards, except for Amégnran market, imported rice prices in Lomé has become substantially higher than prices on other domestic markets of imported rice between the first semester of 2008 and the first semester of 2014. This could indicate that rice traders have seized the opportunity of prices increase on the global market to exert market power by maintaining prices higher in Lomé given the great demand for the imported rice in Lomé.

Descriptive statistics show that average prices of the local rice of paddy and processed rice estimated to be respectively 148.05 FCFA/Kg and 288.28 FCFA/Kg are above average prices of rice on the world market (see table 1). But prices of the processed rice represent on average almost the double of paddy prices. This difference between producer and consumer prices of the local rice is consistent with the findings of Koffi-Tessio *et al.* (2008) that margins are relatively high in cereals marketing in Togo. For the imported rice, the highest average prices is found in the Amégnran market (423.88 FCFA/Kg) followed by Lomé (398.82 FCFA/Kg).

The correlation coefficients between prices on domestic and the world markets are relatively high and positives varying from 0.54 between Amégnran and the world markets to 0.86 between Cinkassé and the world rice markets. This implies

FIGURE 1

LOCAL AND WORLD PRICES OF RICE IN CFA FRANCS PER KILOGRAM (2000-2014)



SOURCE : Author's realization using DSID and FAO/GIEWS data.

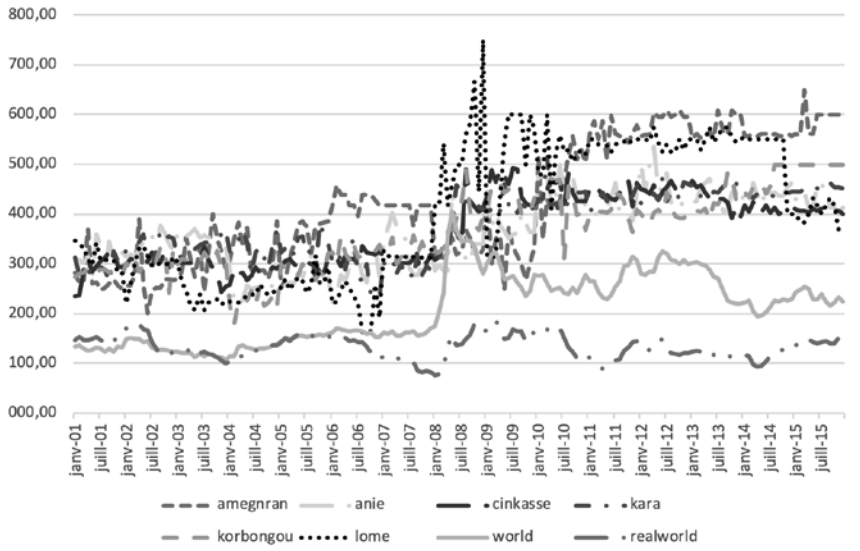
that there is a strong positive relationship between prices on domestic markets of local and imported rice and the world market. Concerning prices variability, except for local markets of paddy and processed rice, descriptive statistics indicate that even though prices fluctuations on domestic markets of the imported rice are to certain extent driven by prices change on the world market, once these shocks are transmitted to domestic markets, the latter become more unstable afterwards. Prices volatility is more perceptible in Lomé and on the Amégnran market where prices variations from one month to another are estimated to be 124.24 FCFA/Kg and 137.82 FCFA/Kg respectively.

2.3 *Methods*

Our methodology consist of testing the existence of a stable long-run relationship between prices pairs on domestic markets of local and imported rice and the world rice market. If these prices pairs are cointegrated, then we determine the extent to which world prices signals are transmitted to domestic markets in Togo and test whether the adjustment processes are linear or exhibits threshold non-linearity. When the adjustment process is found to be non-linear, then we test for asymmetry in the adjustment process.

FIGURE 2

IMPORTED AND WORLD PRICES OF RICE IN CFA FRANCS PER KILOGRAM (2001 – 2015)



SOURCE : Author's realization using FAO/GIEWS data.

2.3.1 *Standard cointegration and the corresponding error correction model*

Prior to the standard cointegration tests, we have studied the statistical properties of all series following the Augmented Dickey-Fuller (ADF) unit root tests to make sure these series come from non-stationary processes. If the unit root tests reveal that prices are integrated of the same order, then we test for cointegration relationship between these prices using both Engle and Granger (1987) and Johansen (1988) cointegration tests. Following Engle-Granger two-stage approach (for brevity), the long-run relationship between a pair of prices is specified as follows:

$$p_t^d = \alpha + \beta p_t^w + \mu_t, \tag{1}$$

where p_t^d and p_t^w represent domestic and the world market prices of rice respectively, α and β are parameters to be estimated and μ_t is an error term. The parameter β denotes the long-run price transmission elasticity (with the logarithms of p_t^d and p_t^w). It measures the extent to which prices change on the world market are transmitted to domestic markets of local and imported rice in Togo.

TABLE 1

DESCRIPTIVE STATISTICS OF DOMESTIC AND WORLD RICE PRICES IN CFA FRANCS PER KILOGRAM

Markets	Obs.	Period	Mean	Standard deviation	Minimum	Maximum	Correlation coefficient
Local rice							
Paddy	180	2000.01 – 2014.12	148.05	35.19	83.00	250.85	0.91
Processed rice	180	2000.01 – 2014.12	288.28	60.53	195.00	407.96	0.80
Imported rice							
Cinkassé	180	2001.01 – 2015.12	368.12	70.50	235.00	493.00	0.86
Korbongou	180	2001.01 – 2015.12	365.05	80.58	178.00	500.00	0.70
Kara	180	2001.01 – 2015.12	377.34	66.16	230.00	514.00	0.75
Anié	180	2001.01 – 2015.12	365.56	72.56	216.00	535.00	0.61
Lomé	180	2001.01 – 2015.12	398.82	124.24	161.00	750.00	0.80
Amégnran	180	2001.01 – 2015.12	423.88	137.82	200.00	650.00	0.54
World market							
Thaï rice	180	2001. 01 – 2015. 12	207.53	70.51	106.76	404.81	

NOTE : Author's calculation using DSID and FAO/GIEWS data.

The Engle and Granger cointegration tests consist of determining whether residuals from the long-run relationship are stationary or not following equation (2):

$$\Delta\mu_t = \rho\,\mu_{t-1} + \sum_{i=1}^{p} \delta_i \Delta\mu_{t-i} + \varepsilon_t, \tag{2}$$

where ρ is the speed of convergence, δ_i are other parameters to be estimated, p is the number of lags (here and thereafter), ε_t is a white noise disturbance term. If the residuals are stationary, the pair of prices involved are cointegrated and assuming that domestic prices change are driven by changes in these prices on the world market, there may exist a corresponding error correction representation following equation (3):

$$\Delta p_t^d = \alpha + \gamma\mu_{t-1} + \sum_{k=1}^{p} \eta_k \Delta p_{t-k}^w + \sum_{k=0}^{p} \beta_k \Delta p_{t-k}^w + \varepsilon_t, \tag{3}$$

where the lagged residual from the long-run relationship is μ_{t-1} ; γ is the speed of adjustment, η_k and β_k are the short-run price transmission elasticities. The number of lags p in equation (2) and (3) and further are selected using Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), the Ljung-Box statistics are used in addressing serial correlation problem.

The standard cointegration analysis assumes that there is an instantaneous adjustment process in the short-run and implies that the parameters of the error correction model are constants over the sample period (Hassouneh *et al.*, 2012). However, many studies have shown that at least one of these implications of the linearity assumption is not valid (von Cramon-Taubadel, 1998; Hassouneh *et al.*, 2010). Theoretically, there are many reasons invalidating the assumption of linearity (see Hansen, 1999).

The most important of these reasons is the presence of "high" transaction costs (Stigler *et al.*, 2012). In effect, price adjustment occurs sometimes only when deviations from the long-run equilibrium are above a certain threshold. A second argument that supports non-linear adjustment process is the presence of market power in the marketing system (see Meyer and von Cramon-Taubadel, 2004). Thus, given the importance of transaction costs and the presence of an oligopolistic power in the rice marketing system in Togo, threshold cointegration may be useful for a better understanding of domestic rice markets behavior with respect to changes in rice prices on the global market.

2.3.2 *Threshold cointegration analysis*

In the threshold cointegration introduced by Balke and Fomby (1997), deviations from the long-run equilibrium are adjusted only when they exceed a critical threshold. This allows an inaction or no-arbitrage band to take place in the ad-

justment process (Goodwin and Piggott, 2001; Stigler *et al.*, 2012). Following Enders and Granger (1998), the threshold cointegration tests consist of validating a threshold autoregressive (TAR) model or a momentum threshold autoregressive (MTAR) model:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1-I_t)\rho_2\mu_{t-1} + \sum_{i=2}^{p}\theta_i\Delta\mu_{t-i} + \varepsilon_t, \tag{4}$$

where μ_t is the residual from the long-run relationship supposed to be independent of the white-noise disturbance term ε_t ; ρ_1, ρ_2 are speeds of adjustment, θ_i are other parameters to be estimated. I_t is the Heaviside indicator function defined for a zero threshold as follows:

$$I_t = \begin{cases} 1 \text{ if } \mu_{t-1} \geq 0 \\ 0 \text{ if } \mu_{t-1} \prec 0 \end{cases} \quad \text{(5a)} \quad \text{or} \quad I_t = \begin{cases} 1 \text{ if } \Delta\mu_{t-1} \geq 0 \\ 0 \text{ if } \Delta\mu_{t-1} \prec 0 \end{cases} \quad \text{(5b)}$$

Equations (4) and (5a) together define the TAR model and equations (4) and (5b) define the MTAR model (for details on the TAR and MTAR models, see Enders and Granger, 1998).

For a null threshold value, $\mu_{t-1} = 0$ can be considered as the long-run equilibrium. Thus, if $\mu_{t-1} \geq 0$, it means all other things being equal that, rice prices decrease on the world market have led to positive deviations from the long-run equilibrium and so the adjustment process is carried out through the regime $\rho_1\mu_{t-1}$. On the other hand, if $\mu_{t-1} \prec 0$, it means that prices increase on the world market have led to negative deviations from the long-run equilibrium and so the adjustment process is carried out through the regime $\rho_2\mu_{t-1}$. Moreover, if $|\rho_1| \leq |\rho_2|$ then the transmission of prices increase on the world market tends to persist whereas decreases are more quickly adjusted.

Since there is no reason a priori for thresholds values to be null, these values are consistently estimated as other parameters in this paper following the approach developed by Chan (1993). So, for a threshold value τ, the Heaviside indicator function in the TAR and MTAR representations are as follows:

$$I_t = \begin{cases} 1 \text{ if } \mu_{t-1} \geq \tau \\ 0 \text{ if } \mu_{t-1} \prec \tau \end{cases} \quad \text{(6a)} \quad \text{or} \quad I_t = \begin{cases} 1 \text{ if } \Delta\mu_{t-1} \geq \tau \\ 0 \text{ if } \Delta\mu_{t-1} \prec \tau \end{cases} \quad \text{(6b)}$$

In the Enders and Granger (1998) cointegration analysis, two categories of tests allows to validating the presence of threshold effect and asymmetry. The first category consists of testing the null hypothesis of no-cointegration. For this test, we can use the T-max which corresponds to the largest value of t-statistics of the null hypotheses: $H_0 : \rho_1 = 0$ and $H_0 : \rho_2 = 0$ or the non-standard Fisher statistic (ϕ) for the complementary joint null hypothesis: $H_0 : \rho_1 = \rho_2 = 0$ against the alternative hypotheses of threshold cointegration in both TAR and MTAR speci-

fications. We focus here on the non-standard Fisher statistic as it is deemed to be more powerful than the T-max. Critical values of the non-standard F-test are from Enders and Siklos (2001).

The second category of the tests concerns the standard Fisher test of equality of the coefficients ρ_1 and ρ_2 which allows to test for the null hypothesis of symmetry: $H_0 : \rho_1 = \rho_2$ against the alternative hypothesis of asymmetric adjustment to the long-run equilibrium. If the first category of test or both tests are conclusive, an asymmetric error correction model is then estimated to investigate whether prices dynamics exhibit non-linearity in the short-run or not and test for asymmetry in the short-run adjustment process.

2.3.3 *Estimation of asymmetric error correction models*

We have made use of the asymmetric error correction model developed by Sun (2011) in his study of price dynamics in the imported wooden bed markets in the United States. The model allows possible asymmetry in the prices dynamics and incorporates the effect of threshold cointegration by embodying the Heaviside indicator function. The model is specified as follows (for detailed information about the model, see Sun, 2011):

$$\begin{aligned}\Delta p_t^d =& \alpha + \gamma^+ \mu_{t-1}^+ + \gamma^- \mu_{t-1}^- + \sum_{k=1}^{p} \eta_k^+ \Delta^+ p_{t-k}^d + \sum_{k=1}^{p} \eta_k^- \Delta^- p_{t-k}^d \\ &+ \sum_{k=0}^{p} \beta_k^+ \Delta^+ p_{t-k}^w + \sum_{k=0}^{p} \beta_k^- \Delta^- p_{t-k}^w + \varepsilon_t,\end{aligned} \tag{7}$$

where α, γ, η and β are parameters to be estimated. γ^+ and γ^- are the speeds of convergence for positive and negative deviations. η_k^+ and η_k^- represent the effects of own lagged prices change whereas β_k^+ and β_k^- represent the short-run price transmission elasticities for positive and negative deviations at selected lag order k. Following equation (7), several tests of asymmetry can be performed (see Frey and Manera, 2007). With respect to our objective, we focus on two categories of tests. The first category of tests concerns the null hypotheses of symmetry in the cumulative price transmission elasticity for positive and negative deviations H_{01} : $\sum_{k=1} \eta_k^+ = \sum_{k=1} \eta_k^-$ (own lagged prices change) and $H_{02} : \sum_{k=1} \beta_k^+ = \sum_{k=1} \beta_k^-$ (lagged prices change on the central market) for an appropriate selected lag order k. The second category of tests concerns the null hypothesis of symmetry in the short-run speed of adjustment $H_{03} : \gamma^+ = \gamma^-$.

3. RESULTS OF THE ESTIMATIONS

Rice prices shocks on the world market are transmitted first to domestic markets of imported rice. Changes in domestic markets of imported rice are then transmitted to the local market of processed rice through substitution effect (see

Tchabletienne *et al.*, 2010). Along the marketing chain, prices change on the local market of processed rice will affect paddy prices.

3.1 *Results of unit root tests*

As the unit root tests are sensitive to deterministic regressors, Enders (2004) has recommended the inclusion of the intercept and trend in the estimation of equation (2). The results reported in table 2 indicate that at 5% significance level, the hypothesis of the presence of unit roots cannot be rejected for all series in level. However, at the same significance level, all of these series are stationary in first difference. The results imply that these series are integrated of the same order one and postulate a possible long-run relationship between different markets pairings. Therefore, cointegration tests are performed.

3.2 *Results of standard and threshold cointegration tests*

3.2.1 *Results of standard cointegration tests*

Engle-Granger and Johansen cointegration tests are performed in this paper. Following Engle-Granger cointegration tests, the results reported in table 3 indicate that at 1% significance level, the null hypothesis of no-cointegration is rejected for all pairs of prices. For Johansen's cointegration tests, except for Amégnran-Lomé prices pair where Lomé is considered as central market, both the trace and the maximum eigenvalue statistics indicate that at 10% significance level, overall, the null hypothesis of zero cointegrating vector is rejected. Hence, there is a stable long-run relationship between rice prices pairings considered in this study.

Therefore, the extent to which global rice prices change are transmitted to domestic markets are estimated taking the logarithms of prices in equation (1). The results reported in table 4 indicate that with exception to the long-run relationships paddy-processed rice, Lomé-Word where price transmission elasticities are relatively high (0.89 and 0.63 respectively), price transmission elasticities are found to be on the lower side ranging from 0.28 in Kara to 0.38 in Cinkassé. The results are not surprising in the context of cereals price control policies in Togo with the objective to isolate domestic markets from prices volatility on the global market.

In this respect, Kumar and Sharma (2003) argue that as long as developing countries have the possibility to protect producers and consumers from external prices shocks, global to local price transmission will remain incomplete. Nevertheless, our results contrast a little bit with the synthesis of Baltzer (2013) that governments in developing countries have not succeeded in isolating domestic markets from food prices fluctuations on the global market.

3.2.2 *Results of threshold cointegration tests*

Following equations 5 and 6, four (4) types of models are estimated for threshold cointegration analyses: consistent TAR and MTAR, and TAR and MTAR for

a null threshold. A number of lags of 12 is tried first and the optimal number of lags included in each model is determined following AIC, BIC and the Ljung-Box statistics so that error terms in the models approximate white noise.

We are aware of the demonstration of Eitrheim and Teräsvirta (1996) that in non-linear models, the Ljung-Box statistic does not follow the standard χ^2. So, the Ljung-Box statistics are used here with caution. Overall, the consistent estimation of the MTAR model is deemed to be the best fit when the global market is considered as the central market for the relationship between the global and domestic markets but the consistent TAR is the best fit when Lomé market is considered as the central market for the relationship between imported rice markets in Togo following the AIC and BIC criterions. For this reason, we have reported in table 5 only the results of the estimations of these consistent TAR and MTAR models (the results of the estimations of other models are available upon request).

The case of local markets of paddy and processed rice

The results reported in table 5 indicate that for the long-run relationship processed rice-World, the null hypothesis of no-cointegration is not rejected. In effect, the nonstandard Fisher statistic ϕ for the null hypothesis $\rho_1 = \rho_2 = 0$ estimated to be 3.416 is less than the critical values of the test at the conventional significance levels. However, this hypothesis is rejected for the long-run relationship between paddy and processed-rice. For the latter, the ϕ statistic for the null hypothesis $\rho_1 = \rho_2 = 0$ estimated to be 21.158 is significant at 1% significance level implying that these prices are cointegrated and the adjustment of paddy prices to processed rice prices change exhibits threshold non-linearity.

Since the adjustment of paddy prices to processed rice prices change exhibits threshold non-linearity, we then test for asymmetry in the long-run adjustment process. The Fisher statistic for the null hypothesis $\rho_1 = \rho_2$ estimated to be 11.643 is greater than the critical value at 1% significance level. So, we reject the null hypothesis of symmetry and conclude that the long-run relationship between paddy and processed rice prices is nonlinear and asymmetric. It means that oligopolistic middlemen in Togo do not transmit processed rice prices change to paddy prices unless changes in deviations from the long-run equilibrium exceed or are in absolute term equal to 2.208 CFA francs per kilogram and positive deviations from the long-run equilibrium (ρ_1) and negative deviations from the long-run equilibrium (ρ_2) are not resorbed at the same magnitude.

TABLE 2

RESULTS OF UNIT ROOT TESTS

Markets	**ADF**	**ADF (with drift)**	**ADF (with trend)**	**ADF**	**ADF (with drift)**	**ADF (with trend)**
	Series in level			**Series in first difference**		
Local rice markets						
Paddy	0.63 [13]	−1.19 [13]	−3.68** [15]	−3.65*** [12]	−3.75** [12]	−3.76** [12]
Processed rice	0.76 [13]	−1.19 [13]	−3.32* [13]	−3.00*** [12]	−3.17** [12]	−3.15* [12]
Imported rice markets						
Cinkasse	0.48 [2]	−1.61 [2]	−1.79 [2]	−12.69*** [1]	−12.70*** [1]	−12.97*** [1]
Korbongou	1.04 [4]	−0.64 [4]	−2.59 [4]	−9.34*** [3]	−9.43*** [3]	−9.42*** [3]
Kara	0.72 [3]	−1.45 [3]	−2.42 [3]	−11.30*** [2]	−11.34*** [2]	−11.31*** [2]
Anie	0.01 [2]	−2.03 [2]	−3.08 [2]	−12.78*** [1]	−13.72*** [1]	−13.72*** [1]
Amegnran	1.06 [7]	−0.92 [7]	−2.33 [7]	−5.11*** [6]	−5.30*** [6]	−5.28*** [6]
Lome	−0.16 [6]	−1.30 [15]	−1.30 [15]	−8.37*** [5]	−8.35*** [5]	−8.35*** [5]
Global market						
Thaï rice 100% B	−0.24 [9]	−1.98 [9]	−2.25 [9]	−3.92*** [8]	−3.98** [8]	−3.97** [8]

NOTE : ADF: Augmented Dickey-Fuller. Critical values are −2.66; −1.95 and 1.60 for ADF test without drift and trend ; −3.46; −2.88 and −2.57 for ADF test with drift; −3.99; −3.43 and −3.13 for ADF test trend for respectively 1%; 5% and 10% significance levels. Values in square brackets represent the number of lags necessary for error terms to approximate white noise in the ADF test. (***), (**) and (*) represent 1%; 5% and 10% significance levels respectively.

TABLE 3

RESULTS OF ENGLE AND GRANGER (1987) AND JOHANSEN (1988) COINTEGRATION TESTS

Markets	**ADF**	**P.Q_{LB}(4)**	**P.Q_{LB}(8)**	**P.Q_{LB}(12)**	**Hypotheses**	**Trace statistic**	**Maximal eigenvalue statistic**
	Engle-Granger test	**Diagnostics (Engle-Granger)**			**Johansen's test**		
Local rice markets							
Paddy-Processed rice	-7.26^{***} [28]	0.9927	0.9776	0.1879	None	43.24^{***}	38.74^{***}
	-	-	-	-	At most 1	4.50	4.50
Processed rice-World	-10.56^{***} [15]	0.8484	0.3508	0.2269	None	24.77^{***}	21.86^{***}
	-	-	-	-	At most 1	290	2.90
Imported rice markets (World as central market)							
Cinkassé-World	-10.21^{***} [12]	0.9773	0.9976	0.9986	None	30.24^{***}	26.22^{***}
	-	-	-	-	At most 1	4.02	4.02
Korbongou-World	-9.32^{***} [11]	0.9889	0.9998	0.5419	None	26.39^{**}	18.01^{*}
	-	-	-	-	At most 1	8.38	8.38
Kara-World	-7.35^{***} [10]	0.9015	0.9929	0.6824	None	19.01^{**}	15.28^{**}
	-	-	-	-	At most 1	3.82	3.82
Anié-World	-8.48^{***} [10]	0.9494	0.9944	0.1312	None	14.57	10.75
	-	-	-	-	At most 1	3.82	3.82
Amegnran-World	-7.66^{***} [11]	0.9969	0.9988	0.9436	None	24.98^{*}	18.34^{*}
	-	-	-	-	At most 1	6.64	6.64
Lomé-World	-11.81^{***} [11]	0.9895	0.6664	0.2406	None	29.71^{***}	27.24^{***}
	-	-	-	-	At most 1	2.47	2.47

TABLE 3 (continued)

RESULTS OF ENGLE AND GRANGER (1987) AND JOHANSEN (1988) COINTEGRATION TESTS

Markets	**ADF**	**P.Q_{LB}(4)**	**P.Q_{LB}(8)**	**P.Q_{LB}(12)**	**Hypotheses**	**Trace statistic**	**Maximal eigenvalue statistic**
	Engle-Granger test	**Diagnostics (Engle-Granger)**			**Johansen's test**		
Imported rice (Lomé as central market)							
Cinkassé-Lomé	-13.49^{***} [09]	0.9727	0.9909	0.8362	None	34.06^{***}	32.01^{***}
	-	-	-	-	At most 1	2.05	2.05
Korbongou-Lomé	-11.68^{***} [11]	0.9874	0.9730	0.9148	None	22.45	17.20^{*}
	-	-	-	-	At most 1	5.24	5.24
Kara-Lomé	-11.15^{***} [08]	0.9922	0.9469	0.1871	None	20.18^{**}	17.68^{**}
	-	-	-	-	At most 1	2.50	2.50
Anié-Lomé	-10.01^{***} [10]	0.9697	0.9690	0.8074	None	25.01^{***}	22.65^{***}
	-	-	-	-	At most 1	2.36	2.36
Amégnran-Lomé	-9.20^{***} [09]	0.9999	0.9999	0.9992	None	18.98	13.49
	-	-	-	-	At most 1	5.48	5.48

NOTE : ADF: Augmented Dickey-Fuller. Critical values are -2.66; -1.95 and 1.60 for ADF test without drift and trend ; -3.46; -2.88 and -2.57 for ADF test with drift; -3.99; -3.43 and -3.13 for ADF test trend for respectively 1%; 5% and 10% significance levels. Values in square brackets represent the number of lags necessary for error terms to approximate white noise in the ADF test. (***), (**) and (*) represent 1%; 5% and 10% significance levels respectively.

TABLE 4

LONG-RUN RELATIONSHIPS FOR LOCAL-CENTRAL MARKETS PRICES PAIRINGS

Markets	α	β	**Fisher statistic**	**P-value**	**Obs.**
Local rice markets					
Paddy-processed rice	−0.0770	0.8946***	72.25	0.0000	179
	(0.5906)	(0.1053)	-	-	-
Processed rice-World	3.8656***	0.3406***	35.62	0.0000	179
	(0.3046)	(0.0571)	-	-	-
Local rice markets					
Cinkassé-World	3.8684***	0.3844***	49.36	0.0000	179
	(0.2865)	(0.0547)	-	-	-
Korbongou-World	4.0166***	0.3537***	19.57	0.0000	179
	(0.4242)	(0.0800)	-	-	-
Kara-World	4.4263***	0.2833***	20.07	0.0000	179
	(0.3355)	(0.0632)	-	-	-
Anié-World	4.3247***	0.2958***	11.62	0.0008	179
	(0.4610)	(0.0868)	-	-	-
Amégnran-World	4.2433***	0.3379**	5.67	0.0183	179
	(0.7619)	(0.1419)	-	-	-
Lomé-World	2.6174***	0.6252***	38.27	0.0000	179
	(0.5362)	(0.1012)	-	-	-
Real World-Lomé	3.0672***	0.5555***	71.47	0.0000	179
	(0.2243)	(0.0424)	-	-	-

NOTE : Values in brackets are robust standard errors. (***) and (**) represent the 1% and 5% significance levels respectively.

In effect, ρ_1 and ρ_2, the speeds of adjustment towards the long-run equilibrium estimated to be respectively -0.315 and -0.734 (all significant at 1% significance level) are all negative and implies convergence but the speed of adjustment of negative deviations is greater than that of positive deviations. Negative deviations from the long-run equilibrium ($\Delta\mu_{t-1} \prec -2.208$) resulting from periods of processed rice prices increase are resorbed at the rate of 73.4% within a month whereas positive deviations from the long-run equilibrium ($\Delta\mu_{t-1} \geq -2.208$) are resorbed at the rate of 31.5% within a month. In other words, negative deviations from the long-run equilibrium take less than one month and half to be totally digested whereas positive deviations from the long-run equilibrium take more than three months to be totally digested.

It means all other things being equal that oligopolistic middlemen take on average more time in transmitting decreases in the prices of processed rice to paddy prices than increases. This could be in general the signal of exercising market power in rice marketing given the weak negotiating power of rice farmers in paddy prices formation in Togo.

Case of the global and imported rice markets in the North of Togo

The results of threshold cointegration tests (see table 5) for the long-run relationship between prices on domestic markets of imported rice (Cinkassé, Korbongou and Kara) and the World market reveal that at the conventional significance level, the null hypothesis of no-cointegration is not rejected for the pair of prices Kara-World. However, this hypothesis is rejected at 1% and 10% significance levels for the pairs Cinkasse-World and Korbongou-World respectively. It implies that these pairs of prices are cointegrated and exhibit threshold nonlinearity so that rice prices change on the global market are adjusted on Cinkassé and Korbongou markets only when changes in the deviations from the long-run equilibrium exceed 4.511 CFA francs and 7.42 CFA francs respectively. For the test of asymmetry, the Fisher test of equality $\rho_1 = \rho_2$ shows that for the pair Korbongou-World, at the 10% significance level, the null hypothesis of symmetry is not rejected but it is rejected at the 1% significance level for the pair Cinkassé-World.

Thus, while the two pairs exhibit threshold nonlinearity, only the imported rice market of Cinkassé adjust asymmetrically to rice prices change on the global market. For the latter, the point estimate for $\rho_1 = -0.348$ (significant at the 1% significance level) and for $\rho_2 = 0.080$ (not significant) suggest that positive deviations from the long-run equilibrium ($\Delta\mu_{t-1} \geq -4.511$) are digested at the rate of 34.8% within a month but this market seem to respond not to negative deviations from the long-run equilibrium ($\Delta\mu_{t-1} \prec -4.511$).

TABLE 5

RESULTS OF CONSISTENT TAR AND MTAR ESTIMATIONS

Markets	**Threshold (a)**	ρ_1	ρ_2	$\phi(H_0: \rho_1 = \rho_2 = 0)$ **(b)**	$F(H_0: \rho_1 = \rho_2)$ **(c)**	**AIC**	**BIC**	**P.Q$_{LB}$(4)**	**P.Q$_{LB}$(8)**	**P.Q$_{LB}$(12)**
	Coefficients			**Hypotheses tests**		**Diagnostic tests**				
Results of consistent MTAR: Local markets										
Paddy-Processed rice	−2.808	-0.315^{***}	-0.734^{***}	21.158^{***}	11.643^{***}	1374.602	1396.756	0.996	0.272	0.284
	[4]	(0.102)	(0.114)	[6.32]	[0.001]	-	-	-	-	-
Processed rice-World	−8.221	-0.127^{**}	0.095	3.416	6.116^{**}	1513.814	1548.373	0.612	0.859	0.569
	[8]	(0.066)	(0.082)	[6.32]	[0.014]	-	-	-	-	-
Results of consistent MTAR : Imported rice markets (World as central market)										
Cinkasse-World	−4.511	-0.348^{***}	0.088	20.490^{***}	24.674^{***}	1582.895	1595.622	0.475	0.738	0.266
	[1]	(0.056)	(0.071)	[6.63]	[0.000]	-	-	-	-	-
Korbongou-World	7.42	−0.053	-0.165^{***}	5.770^{*}	1.341	1740.394	1753.121	0.725	0.365	0.553
	[1]	(0.085)	(0.049)	[6.63]	[0.248]	-	-	-	-	-
Kara-World	4.671	0.028	-0.123^{***}	2.581	2.373	1637.635	1659.789	0.973	0.892	0.796
	[4]	(0.089)	(0.056)	[6.32]	[0.125]	-	-	-	-	-
Anie-World	14.066	-0.210^{***}	-0.110^{***}	5.689^{*}	1.194	1735.235	1747.962	0.494	0.274	0.503
	[1]	(0.080)	(0.049)	[6.63]	[0.276)	-	-	-	-	-
Amegnran-World	−2.113	-0.117^{***}	0.036	3.957	6.196^{**}	1810.772	1832.926	0.990	0.406	0.726
	[4]	(0.044)	(0.045)	[6.32]	[0.014]	-	-	-	-	-
Lome-World	27.674	-0.706^{***}	-0.122^{*}	13.309^{***}	18.664^{***}	1894.715	1926.190	0.926	0.694	0.199
	[7]	(0.137)	(0.076)	[6.32]	[0.000]	-	-	-	-	-
Real World-Lomé	30.542	-0.869^{***}	-0.123^{*}	18.459^{***}	39.358^{***}	1843.645	1881.275	0.544	0.237	0.136
	[9]	(0.144)	(0.083)	[6.32]	[0.000]	-	-	-	-	-

TABLE 5 (continued)

RESULTS OF CONSISTENT TAR AND MTAR ESTIMATIONS

Markets	**Threshold (a)**	ρ_1	ρ_2	$\phi(H_0: \rho_1 = \rho_2 = 0)$ **(b)**	$F(H_0: \rho_1 = \rho_2)$ **(c)**	**AIC**	**BIC**	**P.Q$_{LB}$(4)**	**P.Q$_{LB}$(8)**	**P.Q$_{LB}$(12)**
	Coefficients			**Hypotheses tests**		**Diagnostic tests**				
Results of consistent TAR: Imported rice (Lomé as central market)										
Cinkassé-Lomé	−22.635	-0.196^{***}	-0.638^{***}	23.429^{***}	13.917^{***}	1702.244	1714.971	0.539	0.270	0.219
	[1]	(0.078)	(0.097)	[6.93]	[0.000]	-	-	-	-	-
Korbongou-Lomé	−54.023	-0.166^{***}	-0.531^{***}	19.687^{***}	10.716^{***}	1808.531	1818.093	0.391	0.305	0.282
	[0]	(0.057)	(0.095)	[6.93]	[0.000]	-	-	-	-	-
Kara-Lomé	37.096	0.107	-0.282^{***}	8.003^{**}	12.852^{***}	1646.832	1675.211	0.996	0.802	0.940
	[6]	(0.095)	(0.083)	[7.56]	[0.000]	-	-	-	-	-
Anié-Lomé	−56.544	-0.133^{*}	-0.433^{***}	13.727^{***}	7.639^{***}	1791.644	1804.372	0.883	0.144	0.349
	[1]	(0.074)	(0.086)	[6.93]	[0.006)	-	-	-	-	-
Amégnran-Lomé	−119.97	−0.018	-0.166^{***}	3.811	3.685^{*}	1902.322	1918.203	0.535	0.429	0.703
	[2]	(0.052)	(0.060)	[7.56]	[0.057]	-	-	-	-	-

NOTE : Coefficients in parentheses are standard errors. Values in square brackets in column (a) represent the number of sufficient lags for errors terms to approximate white noise in MTAR models estimations. These values in column (b) represent the 5% critical values for the threshold cointegration tests from Enders and Siklos (2001); in column (c), they represent P-values for asymmetry tests. (***), (**) and (*) represent respectively the 1%, 5% and 10% significance levels.

It means that while the oligopolistic middlemen on the Cinkassé market take a record time to transmit movements of prices decrease on the world market, they take more time than necessary in transmitting movements of rice prices increase on the global market. The fact that Cinkassé market is the farthest from Lomé and exchanges with markets of Burkina Faso as it is located at the border between Togo and Burkina Faso, asymmetric information on transactions costs might have given to the oligopolistic middlemen, all other things being equal the opportunity to maintaining rice prices relatively high even when these prices are decreasing on the global market.

Case of the global and imported rice markets in the South of Togo

The results of the estimations of the consistent MTAR models (see table 5) for the relationship between markets in the South of Togo (Amégnran, Anié and Lomé) and the global market indicate that the null hypothesis of no-cointegration is not rejected for the long-run relationship between prices on Amégnran and the World markets. Indeed, the value of the statistic of the test estimated to be 3.957 is less than the critical values at conventional significance levels. However, this hypothesis is rejected at 10% significance level for the pair Anié-World and at 1% significance level for the pair Lomé-World. It means that the imported rice prices on Anié and Lomé markets and rice prices on the global market are cointegrated and exhibit threshold nonlinearity so that prices are adjusted on these markets when changes in deviations from the long-run equilibrium exceed 14.066 CFA francs per kilogram for Anié-World and 27.674 CFA francs per kilogram for Lomé-World. Then, we test for asymmetry in the adjustment process.

Asymmetric tests reveal that the null hypothesis of symmetry $\rho_1 = \rho_2$ is not rejected for the pair Anié-World whereas it is rejected for the pairs Lomé-world. In effect, the value of the statistic of test estimated to be 1.194 on the Anié market is less than the critical values at the conventional significance levels whereas the value of the statistic of the test estimated to be 18.664 for Lomé-World is significant at 1% significance level. So, while the long-run relationship between prices on the domestic markets of imported rice in Anié and Lomé and the global market exhibit threshold nonlinearity, only the market of Lomé adjust asymmetrically to rice prices change on the World market.

The point estimates for $\rho_1 = -0.706$ and $\rho_2 = -0.122$ are all negative and significant implying convergence toward the long-run equilibrium so that positive deviations from the long-run equilibrium ($\Delta\mu_{t-1} \geq 27.674$) resulting from movements of rice prices decrease on the global market are more rapidly adjusted at the rate of 70.6% within a month than negative deviations from the long-run equilibrium ($\Delta\mu_{t-1} \prec -4.511$) resulting from movements of rice prices increase on the global market adjusted at the rate of 12.2% within a month. All other things being equal, the high demand of the imported rice in Lomé the capital of Togo might have given to the oligopolistic middlemen, the opportunity to exercise market power on this market.

The case of Lomé and other imported rice markets in Togo

The results reported in table 5 indicate that except for the relationship between prices on Lomé and Amégnran markets where the null hypothesis of no-cointegration is not rejected, it is rejected at 1% significance level for the rest of the relationships between prices on Lomé and other imported rice markets. So, the long-run relationships between prices on Lomé and these imported rice markets exhibit threshold nonlinearity so that the imported rice prices change on Lomé market are adjusted on these markets only when deviations from the long-run equilibrium exceed a certain threshold. Asymmetric tests for these prices pairings indicate also at 1% significance level that all of the four (4) imported rice markets that exhibit threshold nonlinearity adjust asymmetrically to imported rice prices change on Lomé market. For instance, for the markets pairings Lomé-Cinkassé, Lomé-Korbongou and Lomé-Anié where positive and negative deviations are negative and significant suggesting convergence towards the long-run equilibrium, negative deviations from the long-run equilibrium are adjusted at the rate of 63.8% within a month whereas positive deviations are adjusted at the rate of 19.6% for the pair Lomé-Cinkassé. These parameters are respectively 53.1% and 16.6% for the pair Lomé-Korbongou and respectively 43.3% and 13.3% for the pair Lomé-Anié.

In other words, negative deviations from the long-run equilibrium resulting from periods of imported rice prices increase on Lomé market take less than two months to be totally digested but positive deviations from the long-run equilibrium take more than five months to be totally digested for the pair Lomé-Cinkassé. For the pair Lomé-Korbongou, negative deviations take also less than two months to be totally digested whereas positive deviations take more than six months to be totally digested. Finally, for the pair Lomé-Anié, negative deviations take at least three months to be totally digested whereas positive deviations take more than seven months and half to be totally digested. These results are consistent with the presence of market power in the imported rice marketing in Togo.

Overall, the results of threshold cointegration are conclusive that expect for the local and central markets pairings processed rice-World, Kara-World, Amégnran-World and Lomé-Amégnran, the other long-run relationships exhibit threshold nonlinearity. Concerning asymmetry tests, we have found out that for the local rice, the paddy market in Togo adjust asymmetrically to prices change in the processed rice and for the imported rice, only Cinkassé and Lomé markets adjust asymmetrically to rice prices change on the global market. But for the relationships between Lomé and other imported rice markets, the adjustment process is asymmetric for all the markets for which the long-run relationships exhibit threshold nonlinearity. In line with the results of standard and threshold cointegration analyses, symmetric and asymmetric error correction models are estimated to investigate the short-run prices dynamics and test for asymmetry for pairings for which the long-run relationships exhibit threshold nonlinearity.

3.3 *Results of the estimations of symmetric and asymmetric error correction models*

While the fact that Togo is a small country and so is a price taker could be a sufficient reason for assuming unidirectional causality for the global to local price transmission analysis, there is no reason a priori which allows to assuming the direction of causality for domestic markets pairings. Granger causality tests are therefore performed to insure the direction of causality. Results reported in table 6 indicate as expected that, rice prices on the world market Granger cause prices on domestic markets of the local and imported rice whereas prices on domestic markets of the local and imported rice do not Granger cause prices on the global market. For markets of the rice produced locally, prices of the processed rice Granger cause paddy prices and paddy prices also Granger cause prices of the processed rice. Granger causality tests show for the relationship between domestic markets of imported rice that the imported rice prices on the central market of Lomé Granger cause prices on all other imported rice markets but only prices on domestic markets of Cinkassé and Amégnran Granger cause prices on the central market of Lomé.

3.3.1 *Results of the estimations of symmetric error correction models*

Symmetric error correction models are estimated for the pairings processed rice-world, Kara-world, Amégnran-World and Amégnran-Lomé (the results are reported in table 7). The AIC and BIC together with the Ljung-Box statistics have selected sufficient lags length of two, four, eight and four respectively for the pairings Kara-World, Amégnran-World, processed rice-paddy and Amégnran-Lomé.

Table 7 indicates that only the error correction term in Kara is significant at the 1% significance level. So, in the short-run, prices in Kara adjust so as to resorb 13.6% of deviations from the long-run equilibrium whereas prices in Amégnran and on the market of processed rice do not appear to respond to rice prices change on the global market in the very short-time. Nonetheless, prices change on the processed rice market is significantly influenced by both own and the global prices lagged changes. So the hypothesis of market segmentation is rejected on the processed rice market. Amégnran market does not also respond to the imported rice prices change in Lomé.

The fact that deviations from the long-run equilibrium are not adjusted in a very short-time could suggest that a certain time is necessary for consumers to switch between the processed rice and the imported rice with respect to prices change on the global market. For the imported rice market of Amégran, in the short-run, prices change on that market are determined only by own lagged changes. Given the isolation of this rural market, while connected to Lomé and the global market in the long-run, its prices seem to move independently from prices change on these central markets in the short-run.

TABLE 6

RESULTS OF GRANGER CAUSALITY TESTS

Markets	**Null hypothesis observations**	**Rice prices on the central markets do not Granger cause rice prices on domestic markets in Togo**	**Rice prices on domestic markets in Togo do not Granger cause rice prices on the central markets**
Local rice markets			
Paddy-Processed rice	168	6.4087*** (a)	15.0263*** (b)
	-	[0.0021]	[0.000]
Processed rice-World	174	7.0461***	2.6547
	-	[0.0010]	[0.0732]
Imported rice markets (World as central market)			
Cinkassé-World	174	12.7219***	1.6987
	-	[0.0000]	[0.1860]
Korbongou-World	172	3.464**	0.3796
	-	[0.0336]	[0.6848]
Kara-World	176	9.8294***	0.2236
	-	[0.0000]	[0.7999]
Anié-World	176	9.9869***	2.5031
	-	[0.0019]	[0.1154]
Amegnran-World	176	1.7388**	1.0635
	-	[0.0361]	[0.3967]
Lomé-World	177	3.659**	1.904
	-	[0.0137]	[0.131]

TABLE 6 (continued)

RESULTS OF GRANGER CAUSALITY TESTS

Markets	**Null hypothesis observations**	**Rice prices on the central markets do not Granger cause rice prices on domestic markets in Togo**	**Rice prices on domestic markets in Togo do not Granger cause rice prices on the central markets**
Imported rice (Lomé as central market)			
Cinkassé-Lomé	174	16.382***	16.817***
	-	[0.000]	[0.000]
Korbongou-Lomé	176	5.318*	3.243
	-	[0.070]	[0.198]
Kara-Lomé	176	9.431***	1.854
	-	[0.000]	[0.396]
Anié-Lomé	172	17.076***	2.542
	-	[0.000]	[0.280]
Amégnran-Lomé	174	7.759**	8.063**
	-	[0.021]	[0.018]

NOTE : (a) stands for the null hypothesis: processed rice prices do not Granger cause paddy prices. (b) stands for the null hypothesis : Paddy prices do not Granger cause processed rice prices. Values in square brackets represent the P-values for the Granger causality test. (***) and (**) represent respectively the 1% and 5% significance level.

TABLE 7

RESULTS OF THE ESTIMATIONS OF SYMMETRIC ERRORS CORRECTION MODELS

Parameters	Processed rice-World	Kara-World	Amégnran-World	Amégnran-Lomé
Estimated coefficients				
α	1.880	1.267	4.133	4.213
	(1.448)	(1.783)	(3.017)	(2.974)
γ	-0.059	-0.136^{***}	-0.034	-0.045
	(0.056)	(0.046)	(0.031)	(0.032)
η^1	-0.298^{***}	-0.364^{***}	-0.515^{***}	-0.489^{***}
	(0.090)	(0.077)	(0.078)	(0.078)
η^2	-0.177^{**}	-0.175^{**}	-0.327^{***}	-0.309^{***}
	(0.092)	(0.071)	(0.085)	(0.086)
η^3	-0.180^{**}		-0.209^{**}	-0.244^{***}
	(0.093)		(0.085)	(0.085)
η^4	-0.151^{**}		-0.244^{***}	-0.251^{***}
	(0.087)		(0.075)	(0.074)
η^5	-0.326^{***}			
	(0.084)			
η^6	-0.004			
	(0.083)			
η^7	0.191^{***}			
	(0.079)			
η^8	-0.218^{***}			
	(0.080)			
β^1	-0.073	0.170	0.017	0.050
	(0.124)	(0.136)	(0.231)	(0.059)
β^2	0.151	0.216	-0.105	-0.074
	(0.133)	(0.142)	(0.253)	(0.065)
β^3	0.037		-0.118	-0.085
	(0.134)		(0.252)	(0.065)
β^4	0.226^{**}		0.135	0.013
	(0.131)		(0.230)	(0.058)
β^5	0.159			
	(0.133)			
β^6	0.002			
	(0.133)			

TABLE 7 (suite)

RESULTS OF THE ESTIMATIONS OF SYMMETRIC ERRORS CORRECTION MODELS

Parameters	Processed rice-World	Kara-World	Amégnran-World	Amégnran-Lomé
β^7	−0.145			
	(0.129)			
β^8	0.223**			
	(0.119)			
Diagnostic tests				
AIC	1502.044	1630.187	1794.669	1789.976
BIC	1561.736	1652.420	1829.482	1824.788
$P.Q_{LB}(4)$	0.887	0.117	0.979	0.950
$P.Q_{LB}(8)$	0.972	0.110	0.451	0.422
$P.Q_{LB}(12)$	0.189	0.302	0.743	0.680
Observations	153	171	165	165

NOTE : Values in parentheses are standard errors; (***), (**) and (*) represent respectively the 1%, 5% and 10% significance levels.

3.3.2 *Results of the estimations of asymmetric error correction models*

Asymmetric error correction models are estimated for both global to local and domestic imported rice markets pairings. The results of the short-run global to local markets pairings are reported in table 8. One lag is selected for the pairings paddy-processed rice and Anié-World, two lags for the pair Korbongou-World and three lags for the rest of markets pairings.

Table 8 indicate that overall, the coefficients associated to positive and negative error correction terms are significant at conventional significance levels for markets pairings in which there is asymmetry in the long-run price dynamics whereas for the rest of markets pairings for which the long-run price dynamics exhibit threshold nonlinearity but not asymmetric adjustment, these coefficients are not significant.

For the local rice markets pairings, a unit positive deviation from the long-run equilibrium resulting from movements of the processed rice prices increase is adjusted at the rate of 33.1% and a unit negative deviation resulting from movements of the processed rice prices decrease is adjusted at the rate of 44.6%. For the imported rice-World prices dynamics, a unit positive deviation from the long-run equilibrium is adjusted in the short-run at the rate of 30.8% at Cinkassé and at the rate of 52.2% in Lomé. As in the long-run, negative deviations are not adjusted on the market of Cinkassé in the short-run but a unit negative deviation from the long-run equilibrium is adjusted at the rate of 20% in Lomé. Asymmetry tests

show that the null hypothesis of symmetry $\gamma^+ = \gamma^-$ in the short-run prices dynamics is rejected for Cinkassé-World and Lomé-World markets pairings whereas it is not rejected for the pair paddy-processed rice.

For asymmetry in the distributed lagged changes, Fisher statistics for the null hypotheses of symmetry: $\sum_{k=1} \eta_k^+ = \sum_{k=1} \eta_k^-$ and $\sum_{k=1} \beta_k^+ = \sum_{k=1} \beta_k^-$ indicate that while both paddy and the processed rice markets do not respond asymmetrically to their own passed prices change, only the processed rice market responds asymmetrically to current and passed paddy prices change at the 1% significance level. Concerning the imported rice markets of Cinkassé and Lomé, they respond asymmetrically to both own, current and passed global market prices change.

For the short-run prices dynamics between domestically separated markets of imported rice in Togo, the results reported in table 9 shows that two lags were necessary for the pairs Korbongou-Lomé and Anié-Lomé whereas three and four lags has been necessary for the respective markets pairings Kara-Lomé and Cinkassé-Lomé. Except for the market pairing Korbongou-Lomé, the coefficients associated to positive and negative error correction terms are all significant and negative suggesting convergence towards the long-run equilibrium and so positive and negative deviations are not adjusted at the same magnitude in the short-run.

For instance at Cinkassé and Anié, positive deviations from the long-run equilibrium are adjusted respectively in the short-run at the rates of 12% and 15.9% whereas negative deviations are adjusted at the rates of 40.1% and 28% respectively. Overall, own lagged prices change and lagged prices change on the central market of Lomé determine together short-run prices change at Cinkassé but own lagged prices change are more determinant in explaining the short-run prices change at Korbongou, Kara and Anié.

Asymmetric tests show that only the imported rice market of Cinkassé adjust asymmetrically to prices change in the central market of Lomé in the short-run. In effect, the Fisher statistic for the null hypothesis of symmetry $\gamma^+ = \gamma^-$ estimated to be 6.188 is significant at 5% significance level while these statistics estimated to be respectively 0.766 (Korbongou-Lomé); 1.172 (Kara-Lomé) and 1.266 (Anié-Lomé) are not significant. For asymmetry in the cumulative distributed lagged changes, the Fisher statistics of the null hypotheses: $\sum_{k=1} \eta_k^+ = \sum_{k=1} \eta_k^-$ and $\sum_{k=1} \beta_k^+ = \sum_{k=1} \beta_k^-$ show that Kara market adjust asymmetrically to its own lagged prices change whereas Cinkassé and Anié markets adjust asymmetrically to the lagged imported rice prices change in Lomé.

TABLE 8

RESULTS OF ESTIMATIONS OF ASYMMETRIC ERRORS CORRECTION MODELS FOR THE GLOBAL TO LOCAL PRICE TRANSMISSION ANALYSIS

Parameters	**Paddy & Processed rice**	**Processed rice & Paddy**	**Cinkassé & World**	**Korbongou & World**	**Anié & World**	**Lomé & World**	**Real World & Lomé**
			Estimated coefficients				
α	2.683**	6.052***	2.489	−5.698	2.264	4.296	0.416
	(1.605)	(2.096)	(2.245)	(4.098)	(3.506)	(5.386)	(5.782)
γ^+	−0.331***	−0.186	−0.308***	0.011	−0.124	−0.522***	−0.709***
	(0.107)	(0.140)	(0.055)	(0.062)	(0.080)	(0.124)	(0.153)
γ^-	−0.446***	0.128	−0.078	−0.142	−0.122**	−0.199***	−0.185***
	(0.128)	(0.168)	(0.076)	(0.094)	(0.050)	(0.064)	(0.071)
η_1^+	0.172	0.602***	−0.385***	−0.251*	−0.398***	−0.662***	−0.398***
	(0.156)	(0.204)	(0.098)	(0.138)	(0.113)	(0.130)	(0.153)
η_2^+			−0.235***	−0.344***		0.201	0.231
			(0.103)	(0.118)		(0.158)	(0.159)
η_3^+			−0.197**			−0.092	−0.054
			(0.102)			(0.151)	(0.151)
η_1^-	0.480***	0.501***	−0.279**	−0.548***	−0.029	0.021	−0.033
	(0.132)	(0.172)	(0.140)	(0.115)	(0.332)	(0.124)	(0.124)
η_2^-			−0.056	0.040		−0.010	−0.035
			(0.143)	(0.062)		(0.125)	(0.125)
η_3^-			0.140			0.076	0.057
			(0.125)			(0.100)	(0.101)

TABLE 8 (continued)

RESULTS OF ESTIMATIONS OF ASYMMETRIC ERRORS CORRECTION MODELS FOR THE GLOBAL TO LOCAL PRICE TRANSMISSION ANALYSIS

Parameters	Paddy & Processed rice	Processed rice & Paddy	Cinkassé & World	Korbongou & World	Anié & World	Lomé & World	Real World & Lomé
Estimated coefficients							
β_1^+	-0.153^{*}	-0.774^{***}	0.489^{***}	0.110	0.609^{***}	0.034	-0.072
	(0.102)	(0.133)	(0.149)	(0.234)	(0.220)	(0.426)	(0.448)
β_2^+			-0.362^{***}	0.213		0.215	0.081
			(0.155)	(0.244)		(0.457)	(0.478)
β_3^+			0.078			-0.526	-0.059
			(0.159)			(0.496)	(0.473)
β_1^-	0.006	0.019	0.060	-0.433	0.029	-1.590^{**}	-0.772
	(0.086)	(0.112)	(0.217)	(0.322)	(0.332)	(0.662)	(0.683)
β_2^-			-0.555^{***}	-0.401		-0.414	-0.462
			(0.202)	(0.322)		(0.618)	(0.647)
β_3^-			-0.175			-0.196	-0.138
			(0.203)			(0.615)	(0.626)
Diagnostic tests							
AIC	1447.183	1523.885	1501.357	1627.612	1727.737	1878.588	1896.673
BIC	1497.911	1574.612	1552.085	1665.726	1753.191	1929.316	1947.400
$P.Q_{LB}(4)$	0.993	0.950	0.303	0.600	0.521	0.875	0.957
$P.Q_{LB}(8)$	0.624	0.430	0.462	0.797	0.374	0.168	0.160
$P.Q_{LB}(12)$	0.225	0.112	0.101	0.927	0.630	0.144	0.150

TABLE 8 (end)

RESULTS OF ESTIMATIONS OF ASYMMETRIC ERRORS CORRECTION MODELS FOR THE GLOBAL TO LOCAL PRICE TRANSMISSION ANALYSIS

Parameters	**Paddy & Processed rice**	**Processed rice & Paddy**	**Cinkassé & World**	**Korbongou & World**	**Anié & World**	**Lomé & World**	**Real World & Lomé**
Hypotheses tests							
$H_{01} : \sum_{i=1} \eta_i^+ = \sum_{i=1} \eta_i^-$	1.902	0.119	6.691**	0.159	3.527*	6.433**	0.419
	[0.170]	[0.731]	[0.011]	[0.691]	[0.062]	[0.012]	[0.518]
$H_{02} : \sum_{i=1} \beta_i^+ = \sum_{i=1} \beta_i^-$	1.246	18.28***	6.562**	5.199**	1.775	2.758*	1.233
	[0.226]	[0.000]	[0.011]	[0.024]	[0.185]	[0.099]	[0.269]
$H_{03} : \gamma^+ = \gamma^-$	0.501	2.195	6.444**	1.348	0.001	5.300**	9.726***
	[0.480]	[0.140]	[0.012]	[0.247]	[0.982]	[0.023]	[0.002]
Observations	171	161	161	160	171	161	161

NOTE : Numbers in parentheses are standard errors whereas those in square brackets are P-values for the asymmetry tests. (***), (**) and (*) represent respectively the 1%, 5% and 10% significance levels.

TABLE 9

RESULTS OF ESTIMATIONS OF ASYMMETRIC ERRORS CORRECTION MODELS FOR THE LOCAL IMPORTED RICE MARKETS PRICES DYNAMICS IN TOGO

Parameters	**Cinkassé-Lomé**	**Korbongou-Lomé**	**Kara-Lomé**	**Anié-Lomé**
Estimated coefficients				
α	-2.057	-0.294	4.893	0.913
	(2.384)	(3.289)	(3.464)	(3.908)
γ^{+}	-0.120^{**}	-0.033	-0.110	-0.159^{**}
	(0.072)	(0.046)	(0.091)	(0.066)
γ^{-}	-0.401^{***}	-0.120	-0.234^{***}	-0.280^{***}
	(0.082)	(0.088)	(0.071)	(0.085)
η_1^{+}	-0.347^{***}	-0.217	-0.377^{***}	-0.338^{***}
	(0.106)	(0.139)	(0.120)	(0.116)
η_2^{+}	-0.172^{*}	-0.323^{***}	-0.242^{*}	-0.175
	(0.117)	(0.118)	(0.129)	(0.120)
η_3^{+}	-0.263^{**}		-0.299^{**}	
	(0.111)		(0.128)	
η_4^{+}	0.041			
	(0.112)			
η_1^{-}	-0.349^{**}	-0.535^{***}	-0.280^{**}	-0.074
	(0.151)	(0.117)	(0.139)	(0.140)
η_2^{-}	-0.029	0.074	-0.165	-0.073
	(0.152)	(0.136)	(0.138)	(0.130)
η_3^{-}	0.130		0.016	
	(0.151)		(0.124)	
η_4^{-}	-0.143			
	(0.133)			
β_1^{+}	-0.070	-0.039	-0.091	-0.092
	(0.046)	(0.071)	(0.062)	(0.077)
β_2^{+}	0.013	-0.041	0.032	0.085
	(0.055)	(0.085)	(0.078)	(0.091)
β_3^{+}	0.069		-0.004	
	(0.055)		(0.075)	
β_4^{+}	-0.105^{*}			
	(0.055)			

TABLE 9 (continued)

RESULTS OF ESTIMATIONS OF ASYMMETRIC ERRORS CORRECTION MODELS FOR THE LOCAL IMPORTED RICE MARKETS PRICES DYNAMICS IN TOGO

Parameters	Cinkassé-Lomé	Korbongou-Lomé	Kara-Lomé	Anié-Lomé
Estimated coefficients				
β_1^-	-0.089^{*}	-0.127^{*}	-0.009	-0.019
	(0.046)	(0.069)	(0.060)	(0.074)
β_2^-	0.013	-0.090	-0.067	-0.178^{***}
	(0.047)	(0.055)	(0.062)	(0.058)
β_3^-	-0.142^{***}		0.005	
	(0.046)		(0.048)	
β_4^-	-0.092^{**}			
	(0.037)			
Diagnostic tests				
AIC	1516.348	1631.143	1638.685	1714.816
BIC	1579.644	1669.257	1689.413	1752.930
P.$Q_{LB}(4)$	0.811	0.504	0.726	0.795
P.$Q_{LB}(8)$	0.977	0.726	0.535	0.744
P.$Q_{LB}(12)$	0.974	0.790	0.635	0.941
Hypotheses tests				
$H_{01} : \sum_{i=1} \eta_i^+ = \sum_{i=1} \eta_i^-$	1.512	0.126	3.005^{*}	1.833
	[0.221]	[0.723]	[0.085]	[0.178]
$H_{02} : \sum_{i=1} \beta_i^+ = \sum_{i=1} \beta_i^-$	5.159^{**}	1.838	0.007	2.758^{*}
	[0.052]	[0.177]	[0.935]	[0.099]
$H_{03} : \gamma^+ = \gamma^-$	6.188^{**}	0.766	1.172	1.266
	[0.014]	[0.383]	[0.283]	[0.262]
Observations	156	160	161	166

NOTE : Numbers in parentheses are standard errors whereas those in square brackets are P-values for the asymmetry tests. (***), (**) and (*) represent respectively the 1%, 5% and 10% significance levels.

3.4 *Robustness check*

While nominal prices are used in the analysis of the relationship between the global and local prices in this study, we have found it important to run Lomé-World price pair regressions with real world and local prices. Indeed, nominal and real prices of rice on the international market from January 2001 to December 2015 shown on figure 2 were almost the same during 2001 and 2005 when inflation was low. But the two prices began to diverge in 2006 and inflation become high during the 2007-2008 global food crisis and afterwards. Moreover, imported rice prices on Lomé market from which almost all the imported rice is distributed to

other domestic markets have become higher than prices on these markets during the global food crisis and afterwards. So, given the fact that rice is a storable consumption good and some increase in rice price coming only from inflation could coincide with increases in the world price for rice and lead to spurious correlation, for robustness check, Lomé-World price pair regressions are also run with real world and local prices.

The results of estimations of real world and local prices pair regressions indicate that, the price transmission elasticity for real Lomé-World is estimated to be 0.56 compared to 0.63 for the pair Lomé-World (see table 4). While these price transmission elasticities are different in magnitude, they lead to the same conclusion that the price transmission elasticity of rice between the World and Lomé markets is relatively high.

As for the pair Lomé-Word, the null hypothesis of no-cointegration is rejected at 1% significance level for the pair real Lomé-World (see table 5). It means that the real Lomé-World prices are cointegrated and exhibit threshold nonlinearity so that prices are adjusted on these markets when changes in deviations from the long-run equilibrium exceed 30.542 CFA francs per kilogram compare to 27.674 CFA francs per kilogram for the pair Lomé-World.

The asymmetry test reveals as for the pair Lomé-World that the null hypothesis of symmetry $\rho_1 = \rho_2$ is rejected at the 1% significance level. So, the imported rice market of Lomé adjust also asymmetrically to the global market rice prices change when Lomé-World price pair regressions are run with real World and local prices in the long-run.

The point estimates for $\rho_1 = -0.869$ and $\rho_2 = -0.123$ are also all negative and significant implying convergence toward the long-run equilibrium so that positive deviations from the long-run equilibrium ($\Delta\mu_{t-1} \geq 30.542$) resulting from movements of rice prices decrease on the global market are more rapidly adjusted at the rate of 86.9% within a month than negative deviations from the long-run equilibrium ($\Delta\mu_{t-1} \prec 30.542$) resulting from movements of rice prices increase on the global market adjusted at the rate of 12.3% within a month.

While the magnitude of the coefficients of Lomé-World and real Lomé-World for positive deviations are a little bit different (whereas the coefficient of positive deviations are equal), the two pairs of regressions lead to the same conclusion that oligopolistic middlemen take on average one month to fully transmit movements of rice prices decrease on the global market but more than eight months in transmitting movements of rice prices increase on the World market.

In the short-run, results of real Lomé-World regressions indicate that, a unit positive deviation from the long-run equilibrium is adjusted at the rate of 70.9% whereas a unit negative deviation from the long-run equilibrium is adjusted at the rate of 18.5% (see table 8). While the magnitude of the coefficients for positive deviations in the short-run price dynamics for real Lomé-World is greater than that of Lomé-World, the magnitude of the coefficients for negative deviations are quite

similar. Asymmetry test reveals that, the null hypothesis of symmetry $\gamma^{+} = \gamma^{-}$ is rejected for the pair real Lomé-World as for the pair Lomé-World. The analyses suggest that, the results of the estimations are somewhat robust to the nature of prices used in the Lomé-World prices pair regressions.

CONCLUSION

In this paper, we have investigated the extent and the speed of adjustment of domestic markets of local and imported rice to prices change on the global market and the response of paddy and the imported rice markets to respectively prices change in the processed rice and on the central imported rice market of Lomé in Togo using both standard and threshold cointegration analyses. The results of the Engle-Granger and Johansen cointegration tests have shown that prices of the central-local markets pairings and between Lomé and other imported rice markets are cointegrated implying the existence of a stable long-run relationship between prices in all markets pairings. Overall, rice prices change on the global market are transmitted to domestic markets of both local and imported rice with relatively low price transmission elasticities. While our results are consistent with the finding of Kumar and Sharma (2003), they contrast a little bit with the synthesis of Baltzer (2013) who have pointed out that African governments' price control policies have not succeeded in isolating domestic markets from the global market price fluctuations.

Threshold cointegration tests reveal the existence of asymmetric adjustment of paddy prices to changes in the processed rice prices and asymmetric adjustment of domestic markets of Cinkassé and Lomé to rice prices change on the global market in the long-run. Four domestic markets of imported rice (Cinkassé, Korbongou, Kara and Anié) adjust also asymmetrically to rice prices change on the central market of Lomé. In the short-run, asymmetry is found only for the relationship between prices in Cinkassé-World, Lome-World (for the global to local price dynamics) and Cinkassé-Lomé (for local imported rice price dynamics) markets pairings.From the robustness check, it comes out that the results of estimations are somewhat robust to the nature of prices used in the Lomé-World prices pairings regressions.

Overall, the results imply that oligopolistic middlemen in rice marketing in Togo are more sensitive and react quickly when rice prices change on the global market tends to squeeze their margins than prices change that stretches them. The prevalence of asymmetry in the adjustment processes could be explained by the presence of high transaction costs, government intervention in the rice marketing in Togo and the weak negotiating power of rice farmers. The results are consistent with the findings of Adjognon (2012) that the greatest rice marketing margins are found in the Maritimes (where Lomé market is located) and Savanna regions (where Cinkassé market is located). Results are also consistent with the findings of Koffi-Tessio *et al.* (2008) that cereals' marketing in Togo is concentrated in the

hands of few people accumulating huge profits from their monopoly positions and asymmetric information on markets conditions.

The results mean that farmers who remain at the beginning of the marketing chain in Togo (or consumers) do not benefit from periods of prices increase (decrease) on the global market. This can lead for instance rice farmers to subsistence farming while in the long-run, the goal of state authorities is to achieve self-sufficiency in rice. So, appropriate policy measures are needed to address market inefficiencies in the rice sector in Togo. In particular, there is a need for policy measures that aim at enhancing rice farmers' market participation in Togo such as improving the quality of existing rural roads and building new feeder roads and market infrastructures. Moreover, policy measures that aim at liberalizing or increasing competition in the rice importing sector in Togo are important to insure an efficient redistribution with respect to prices change on central markets.

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