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Commodity market instability and asymmetries in developing countries:

Development impacts and policies

Les asymétries et l'instabilité du marché des matières premières dans les

pays en développement : politiques et impacts sur le développement

Price transmission and asymmetric adjustment: the case of three West African rice markets

By

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Draft

1. Introduction

Between January 2007 and April 2008, 37 countries across the globe experienced food riots caused by widespread anger over the rapid rise in food prices (Janin, 2009). In West Africa, several countries faced street protests including Senegal, Burkina Faso and Mauritania. Overall, these events revealed the high degree of dependency of many poor countries on global food markets.

The international price of nearly every agricultural commodity sharply increased in 2007 and 2008, creating a global food price bubble. The international prices of traditional staple foods such as maize, rice and wheat surged abruptly, reaching their highest levels in nearly thirty years (FAO, 2009). Dairy products, meat and palm oil also experienced sharp price hikes.

Countries with high food import dependency are highly vulnerable to rising international food prices. The large majority of West African countries are net food importers (FAO, 2011a). Cereals imports in West Africa are dominated by rice and wheat (FAOSTAT, 2013). Over the last two decades, there has been a shift in consumption from traditional cereals to rice, partly because people prefer its cooking qualities and minimal preparation time (Balasubramanian et al., 2007). In coastal countries like Guinea, Guinea Bissau, Liberia, Senegal and Sierra Leone, rice is the major source of calories (FAOSTAT, 2013). As domestic rice consumption increased faster than local rice production, West African countries became increasingly dependent on imports to meet their domestic needs. It does not threaten food security in periods of low prices of imported rice but it becomes problematic in a context of high world prices of rice. Global rice prices rose to record highs in the spring of 2008, with trading prices tripling from November 2007 to May 2008. The causes of this price spike are complex and the price increase of rice was not due to crop failure or a particularly tight global rice supply situation (FAO, 2011b). The rise in rice prices is the result of the combined effects of trade restrictions by major suppliers (India), panic buying by several large importers, a weak dollar, and high oil prices.

The effects of the food crisis have varied between developing countries according to their food import dependency and the degree to which prices on world markets were passed through to domestic prices. Indeed, the magnitude of the impact of increases of the international food prices depends directly on the extent to which those increases are transmitted to domestic markets. The purchasing power of households depends on the level of domestic food prices, not on the level of international food prices. The degree to which prices on world markets are passed through to domestic prices is a crucial issue as it influences the behavior of producers and consumers. Prices serve at signals about what should be produced and consumed and they provide incentives to people to alter their production and consumption. The transmission of increases of the world food prices to domestic prices may provide strong incentives for African smallholders to increase production or may lead to the substitution of imported grains with locally produced cereals.

Price transmission between the world prices and the domestic prices has been widely analyzed in the literature (see Baffes and Gardner, 2003; Conforti, 2004; Gilbert, 2010). A recent FAO study (Rapsomanikis, 2011) analyses the relationship between the world market and the domestic markets in six developing countries including two in sub-Saharan Africa. The study shows that domestic markets are integrated with the world market in the long run but the degree of adjustment of domestic food prices to world market changes is slow. In most of the food importing countries included in the study, domestic prices fully adjust to changes in the international prices after a period of nine to ten months. Meuriot (2012) studies the transmission of the fluctuations in the world price of rice to the domestic prices of imported rice in Dakar and Mpal and to the domestic price of local and imported rice in Bamako. She finds that the prices of imported rice in Dakar and Mpal are integrated in the long-term with the world price of rice whereas she provides evidence of the absence of integration between the Malian markets and the international market of rice.

The current paper investigates price transmission between the international price of rice and the domestic prices of imported rice and local rice in three West African markets in an attempt to determine the impact of the increases in the world rice prices on the West African markets. In this paper, we restrict our attention to three countries: Senegal, Mali and Chad. These three countries are characterized by different consumption and production profiles and by different market structures. Hence, studying the price transmission between the world price of rice and the domestic prices of rice in these three distinct contexts can be instructive. It can help us to understand how the production profile and the market structure influence the degree of price transmission. We focus our analysis on the price of rice in the capitals: Dakar, Bamako and N'Djamena. Besides the issue of the quality of rice, two types of rice are available on these three markets: the imported rice and the local rice. We thus examine the relationship between the international price of rice and the domestic prices of imported and local rice.

After the 2008 sharp rise in the international price of rice, the West African domestic prices of rice increased strongly after a delay of a few months varying with the policies implemented by the countries, the grain supply level and the exchange rate. It took 12 and 8 months respectively to the imported rice prices in N'Djamena and Dakar to go down. These delays are consistent with the general consumers feeling that retail food prices respond faster to an increase in the global food prices than to a decrease. If the domestic prices of imported and local rice respond more fully or rapidly to an increase of the international price of rice than to a decrease, the asymmetry is said positive whereas in the opposite case the asymmetry is said negative. This issue of asymmetric adjustment has been widely discussed in economic literature (see Balke and Fomby 1997, Enders and Siklos 2001) but only few studies have analyzed asymmetric price transmission of agricultural commodities. Among these articles, a few analyze asymmetric vertical price transmission (see Goodwin and Harper 2000, Stigler and Tortora 2011) but none of them focus on the behavior of grain prices in West Africa.

The purpose of this research is twofold. Firstly, we investigate whether the international price of rice is transmitted domestically in three West African countries: Senegal, Chad and Mali. Secondly we investigate whether domestic prices of imported and local rice respond faster to an increase or to a decrease in the international price of rice.

The remainder of the paper is organized as follows. The next section presents the characteristics of rice markets in Senegal, Mali and Chad. Section 3 explains the econometric approach used in the empirical analysis. The results of the empirical analysis are shown in section 4 and the last section concludes.

2. Characteristics of rice markets in Senegal, Mali and Chad

2.1. Rice

Rice has become a commodity of strategic significance across much of Africa. Driven by changing food preferences in the urban and rural areas, by the rapid urbanization and population growth, rice consumption in sub-Saharan Africa increased steadily over the last decade. Grain consumption profiles vary a lot between Senegal, Mali and Chad. Rice provides more than one third of cereal calorie intake in Senegal, 22 percent in Mali and 5 percent in Chad (FAOSTAT, 2013). Even if rice plays a relatively minor role in the diet in Chad, its consumption is rising (see Table A1 in appendix). It is worth noting that 88 percent of the domestic supply of rice is consumed in urban centres in Chad (Bricas et al., 2009) suggesting that rice plays an important role in urban food security.

West Africa's rice production has not been able to match growth in demand resulting in a significant increase in imports. With regional rice imports totaling almost 19 percent of world rice imports (FAOSTAT, 2013), West Africa has become a significant player in world rice markets. Senegal is the third largest West African importers of rice representing 12 percent of regional rice imports and 2.3 percent of world rice imports (FAOSTAT, 2013). The increase in rice imports results from changing food preferences as well as from trade liberalization. At the end of the eighties, there was a shift from state-led development to a gradual liberalization of the rice economy making imported rice cheaper and leading to increased imports.

Senegal relies mainly on imported rice to cover its needs. In Senegal, only 30 percent of domestic rice is sold in urban centers (USAID, 2009a). Local rice enters commercial market channels through large transactions following each harvest and through smaller and irregular transactions throughout the year when farmers are short of cash (USAID, 2009c). Farmers produce rice primarily for subsistence and most of them are not commercially oriented. Such a marketing scheme results in a fragmented and informal rice value chain characterized by a high degree of uncertainty. It is unclear whether the strong preference for imported rice is due to the poor quality of local rice, to a lack of communication promoting local rice or to the lack of availability of local rice on the market.

Conversely, Mali and Chad are among the few West African countries which meet close to 90 percent of domestic needs in rice through national production (Table A1). In Mali large volumes of local rice reach urban markets through collectors, semi-wholesalers and retailers.

The West African rice market is segmented on the basis of the rice quality. This segmentation has important implications in terms of price transmission. In many countries, local rice is considered to be of lower quality than imported rice. Hence, rice producers have to set their price below the price of imported rice to make their product attractive. The price of imported rice puts a cap on the price of locally produced rice. Local rice has to compete with imported rice and the price of local rice may be affected by changes in the world price of rice. However, local rice is an imperfect substitute for imported rice and in some rare cases consumers perceive local rice as a product with specific attributes that cannot be found in imported rice. These qualities allow farmers to sell their rice at a higher price. In those rare cases, local rice does not directly compete with imported rice and then the price of these types of local rice may be less affected by the volatility of the world price of rice. In Mali, both urban and rural consumers strongly prefer local rice for its freshness and taste (USAID, 2009a). The market for local rice is divided into two distinct segments: a segment where a rice of high quality is sold, consisting exclusively of local rice that has been polished and cleaned, and a mass market segment consisting of imported rice and un-cleaned and heterogeneous local rice (USAID, 2009b).

2.2. The domestic markets characteristics explaining asymmetric price transmission

To date, the literature (see Meyer and Von Cramon-Taubadel, 2004, for a review) has examined a variety of factors that can explain the existence of asymmetric price transmission from world prices to domestic markets. We restrict here the potential causes of weak price transmission and asymmetric adjustment to the factors that seem plausible in the context of West African rice markets.

The relationships linking importers, wholesalers and retailers is characterized by high transactions costs that may prevent agents from adjusting prices continuously (Blake and Fomby, 1997). If adjustment is costly, traders may respond to small changes in world prices by increasing or reducing their margins, leading to a zero pass through of small movements in world prices to domestic markets. In Dakar, importers typically maintain a one to three month stock of rice (USAID, 2009a).This reflects not only the relatively long order-cycle (one month or more) but also the need to deal with demand variations. This may imply that small transitory changes in the world price of rice are not transmitted to the domestic price of imported rice. Additionally, retail prices may not adjust fully due to menu costs such as costs of informing market partners as well as the risk to the retailer's reputation if its price changes are too frequent. Finally, sellers may be reluctant to adjust their prices if they ignore whether the price change is permanent or transitory.

Different costs of adjustment, depending on whether prices rise or fall, might be a cause of price asymmetries. For example, the 2008 rise in the international price of rice and the uncertainty about the ability of Asian markets to export sufficient quantities of rice led the West African countries to look for other sources of rice supply. It entails search costs for importers and these costs do not exist in periods of low world price of rice.

Imperfect competition in the processing/distribution chain is frequently reported as a major source of asymmetric price transmission. If some agents have the ability to influence directly or indirectly market prices, they may respond more quickly to shocks that reduce their marketing margins than to shocks that raise them. Imperfect competition may refer to the exercise of market power by a small group of middlemen. In Mali and Senegal, rice imports are highly concentrated among few actors. Two or three main importers make up two-third of all imports in Mali (Baris et al., 2005) while 66 percent of all rice imports flow through only 4 importers in Senegal (USAID, 2009c). The high concentration in rice imports may result in non-competitive situations and asymmetric price transmission. At the wholesale level, margins are the result of what could be described as competitive collusion: wholesalers agree to a standard mark-up that is small and driven by a high turnover strategy. As pointed out by Meyer and Von Cramon-Taubadel (2004), market power can lead to positive or negative asymmetry.

Lastly, asymmetric price adjustment may be caused by political intervention in the form of price support or marketing quotas. Although most West African countries have officially stopped intervening in rice production and marketing following the structural adjustment reforms of the eighties and nineties, governments continue to intervene. In response to the 2008 crisis, the Senegalese government removed temporarily custom duties on rice imports while the Government of Mali grants a temporary VAT exemption for imported rice (Mendez del Villar et al., 2010). In addition, a price control has been imposed over imported rice both in Mali and Senegal in 2008.

3. Model for measuring price transmission

3.1. Cointegration analysis

The first step of the analysis consists in determining whether our price series are cointegrated. Cointegration analysis is applied to examine whether long-run equilibrium exists between the world price of rice and the domestic prices of local and imported rice.

The long run relationship is given as:

$$P^D_t = \alpha_0 + \alpha_1 P^W_t + \mu_t \qquad (1)$$

where P^D_t is the price in domestic market and P^w_t the world price of rice. P^D_t may either be the domestic price of imported rice or the domestic price of local rice. If μ_t is stationary, then market prices are said to be cointegrated. Co-integration implies that these prices move together in the long run, although in the short run they may drift apart. We adopt the Johansen test of cointegration.

If P^D_t and Pwt are co-integrated we can estimate the following error correction model:

$$\Delta P^D_t = \beta_0 + \beta_1 \mu_{t-1} + \sum_{i=1}^{p} \lambda_i \Delta P^W_{t-i} + \sum_{i=1}^{p} \delta_i \Delta P^D_{t-i} + \varepsilon_t \qquad (2)$$

μ_{t-1} is the lagged value of the residual derived from equation (1) and ε_t is a white noise. The error correction coefficient (β_1) reflects the speed of adjustment.

In the standard model of cointegration, the autoregressive process follows a linear AR model. An implicit assumption is that the adjustment to equilibrium is a constant proportion of the error regardless of the size of this deviation. Recent developments in time series analysis techniques have recognized that the speed of adjustment may depend on the magnitude of the deviation. Larger shocks may imply a different response than smaller shocks. The autoregressive process may be non-linear due to the presence of asymmetric costs of adjustment, transactions costs, and other forms of rigidities. Then the adjustment process can be represented trough threshold autoregressive (TAR) model in which the speed of adjustment to equilibrium switches depending on the magnitude of the deviation.

3.2. Estimating a TAR model

Threshold autoregressive models (TAR) consist of m, AR(p) parts where one process changes to another according to the value of an observed variable, a threshold. TAR models are usually referred to as TAR (m,p) where p is the autoregressive order in each regime. The simplest class of TAR models is the Self Exciting Threshold Autoregressive (SETAR) models of order p introduced by Tong (1983) and specified by the following equation:

$$\mu_t \begin{cases} \omega_m + \rho_{m,1}\,\mu_{t-1} + \ldots + \rho_{m,p_m}\mu_{t-pm} + \varepsilon_{mt} & \text{if } \mu_{t-d} \geq \theta_{m-1} \\ \ldots & \text{if } \theta_{m-1} \geq \mu_{t-d} \geq \theta_{m-2} \\ \omega_2 + \rho_{2,1}\mu_{t-1} + \ldots + \rho_{2,p_2}\mu_{t-p2} + \varepsilon_{2t} & \text{if } \theta\ \ldots \geq \mu_{t-d} \geq \theta\ \ldots \\ \omega_1 + \rho_{1,1}\mu_{t-1} + \ldots + \rho_{1,p_1}\mu_{t-p1} + \varepsilon_{1t} & \text{if } \theta_1 \geq \mu_{t-d} \end{cases} \quad (3)$$

where m is the number of regimes; $\omega_1 \ldots \omega_m$ are the intercepts in each regime; $p_{j,1} \ldots p_{j,m-1}$ are the number of lags in regime j ; $\theta_1 \ldots \theta_{m-1}$ are the thresholds; d is the delay of the transition variable and μ_{t-d} is the transition variable.

The SETAR model is a special case of the TAR model where the threshold variable is a certain lagged value of the series itself, an endogenous variable. The main problems in estimating SETAR models are the selection of the correct order of the model and the identification of threshold values and delay parameters. The lag order is selected prior to building a nonlinear model, using suitable information criterion. The Akaike and the Schwartz information criterion are used here. The estimation procedure of the delay parameter of the model is done for each potential value of the delay with $d \leq p$. The model that yields the smallest residual sum of squares makes the most consistent estimate of the delay parameter.

SETAR models with one or two thresholds:

In this paper, we estimate a SETAR model with one or two thresholds. The SETAR (2, p) model posits that the cointegration dynamics are different for deviations below or above a certain threshold θ.

The SETAR (2, p) model takes the form:

$$\mu_t \begin{cases} \omega_2 + \rho_{2,1}\mu_{t-1} + \ldots + \rho_{2,p_2}\mu_{t-p2} + \varepsilon_{2t} & \text{if } \mu_{t-d} > \theta \\ \omega_1 + \rho_{1,1}\mu_{t-1} + \ldots + \rho_{1,p_1}\mu_{t-p1} + \varepsilon_{1t} & \text{if } \mu_{t-d} \leq \theta \end{cases} \quad (4)$$

The corresponding error correction model is given by:

$$\Delta P^D \begin{cases} \nu_2 + \beta_2\,\mu_{t-1} + \sum_{i=1}^{p} \lambda_{2,i}\,\Delta P^W{}_{t-i} + \sum_{i=1}^{p} \delta_{2,i}\Delta P^D{}_{t-i} + \varepsilon_{2,t} & \text{if } \mu_{t-d} > \theta \\ \nu_1 + \beta_1\,\mu_{t-1} + \sum_{i=1}^{p} \lambda_{1,i}\,\Delta P^W{}_{t-i} + \sum_{i=1}^{p} \delta_{1,i}\Delta P^D{}_{t-i} + \varepsilon_{1,t} & \text{if } \mu_{t-d} \leq \theta \end{cases} \quad (5)$$

The SETAR (3, p) model is easier to interpret as the outer regime correspond to large deviations from the long-run equilibrium. The inner regime can be interpreted as containing the small deviations from the long-term equilibrium that are not leading to a price adjustment. Goodwin and Piggott (2001) call this interval the 'neutral band'. This neutral band may result from the existence of transaction costs. Trade may be profitable only outside the band when the transaction costs are lower than the price difference.

The SETAR(3,p) takes the form:

$$\mu_t \begin{cases} \omega_3 + \rho_{3,1}\mu_{t-1} + \ldots + \rho_{3,p_3}\mu_{t-p3} + \varepsilon_{3t} & \text{if } \mu_{t-d} > \theta_2 \\ \omega_2 + \rho_{2,1}\mu_{t-1} + \ldots + \rho_{2,p_2}\mu_{t-p2} + \varepsilon_{2t} & \text{if } \theta_1 < \mu_{t-d} \leq \theta_2 \\ \omega_1 + \rho_{1,1}\mu_{t-1} + \ldots + \rho_{1,p_1}\mu_{t-p1} + \varepsilon_{1t} & \text{if } \mu_{t-d} \leq \theta_1 \end{cases} \quad (6)$$

The corresponding error correction model can be written as:

$$\Delta P^D{}_t \begin{cases} \nu_3 + \beta_3\,\mu_{t-1} + \sum_{i=1}^{p} \lambda_{3,i}\,\Delta P^W{}_{t-i} + \sum_{i=1}^{p} \delta_{3,i}\Delta P^D{}_{t-i} + \varepsilon_{3,t} & \text{if } \mu_{t-d} > \theta_2 \\ \nu_2 + \beta_2\,\mu_{t-1} + \sum_{i=1}^{p} \lambda_{2,i}\,\Delta P^W{}_{t-i} + \sum_{i=1}^{p} \delta_{2,i}\Delta P^D{}_{t-i} + \varepsilon_{2,t} & \text{if } \theta_1 < \mu_{t-d} \leq \theta_2 \\ \nu_1 + \beta_1\,\mu_{t-1} + \sum_{i=1}^{p} \lambda_{1,i}\,\Delta P^W{}_{t-i} + \sum_{i=1}^{p} \delta_{1,i}\Delta P^D{}_{t-i} + \varepsilon_{1,t} & \text{if } \mu_{t-d} \leq \theta_1 \end{cases} \quad (7)$$

3.3. Testing for threshold cointegration

Before estimating a SETAR model, we test for the existence of threshold-type non linearity first following Hansen's procedure (1997).The advantage of Hansen's procedure is that the thresholds can be estimated together with other model parameters and valid confidence intervals can be constructed for the estimated thresholds.

To test the null hypothesis of SETAR (1, p) against the alternative hypothesis of SETAR (2, p), the likelihood ratio test assuming normally distributed errors can be used:

$$F(ij) = \frac{RSS_i - RSS_j}{\hat{\sigma}_j^2(\theta)} = n' \frac{\hat{\sigma}i^2 - \hat{\sigma}_j^2(\theta)}{\hat{\sigma}_j^2(\theta)}$$

where RSS_i is the residual sum of squares from SETAR(1,p), RSSj is the residual sum of squares from SETAR(2,p) given the threshold θ, and $\hat{\sigma}_i^2$ is the residual variance of SETAR(1,p).

Since the threshold θ is usually unknown, Hansen (1997) suggests to compute the following sup-LR test: $F_s = \sup F(\theta)$; $\theta \in \Gamma$ by searching over all the possible values of the threshold variable. In practice, to ensure the model is well identified, a certain percentage of Γ at both ends are usually trimmed and not used.[1] If ε_t is not independent and identically distributed (i.i.d), the F test needs to be replaced by heteroskedasticity consistent Wald or Lagrange multiplier test.

As the transition and threshold parameters appear only under the alternative hypothesis, testing for threshold nonlinearity is a complicated issue. This problem is well known as the nuisance parameters problem (Davies 1987). To deal with the nuisance parameter problem, Hansen shows that the asymptotic distribution may be approximated by a bootstrap procedure.

In the remainder of the paper, we test the null hypothesis of one regime against two, then the null of one regime against three and finally the null of two regimes against three. This strategy allows to determinate the number of thresholds.

4. Data and estimation

4.1. Data and stationary tests

The empirical analysis utilizes monthly retail prices of local and imported rice in three West African countries namely: Senegal, Mali and Chad. Thailand is the major world rice exporter and Senegal and Mali are principally buyers of 100 percent broken rice (USAID, 2009a), so we use the export price of the 100% broken rice in Bangkok as an estimate of the relevant world price. The period of study differs according to the data availability (see Table 1). Domestic price data are coming from the World Food Program[2] and the international price of rice is coming from the Osiriz Infoarroz database[3].

Since the three countries considered are small in terms of rice supply and demand, we make the hypothesis that the prices of rice in these countries have no effect on the export price of rice in Thailand and we examine exclusively the transmission of the international price of rice to domestic prices.

[1] In the following estimations, 15% of extreme values are excluded.
[2] See VAM Food and Commodity Prices Data Store : http://foodprices.vam.wfp.org/Default.aspx
[3] See : http://www.infoarroz.org

Table 1. Prices characteristics

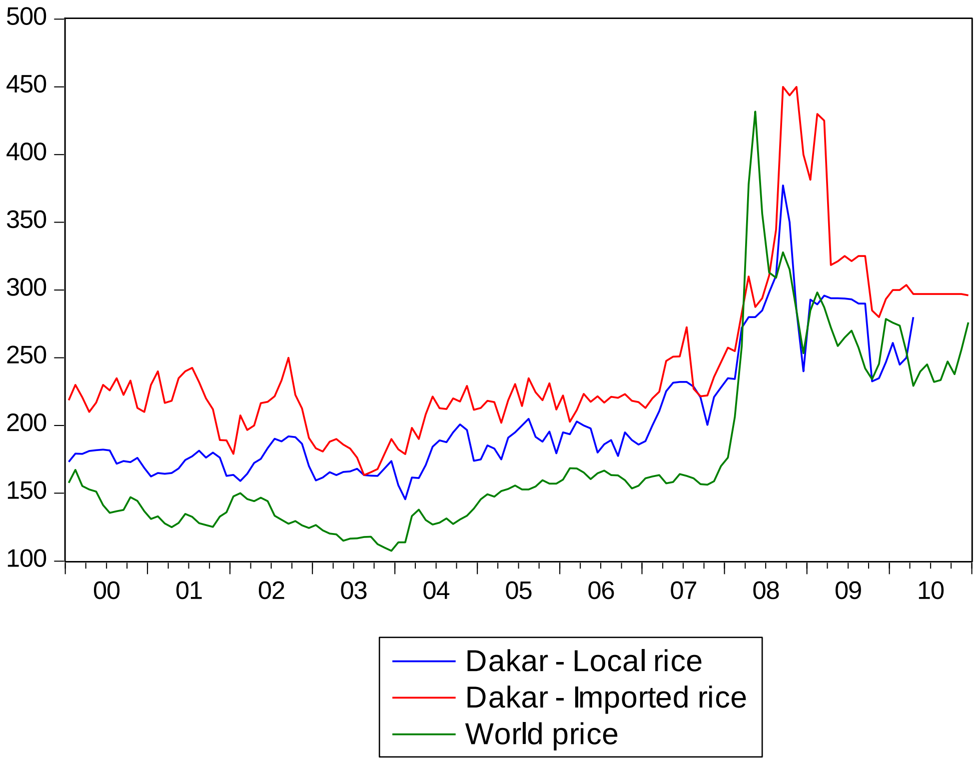
Country	Market	Price type	Period of study	No Obs.	Max	Min	Mean
Senegal	Dakar	Imported rice	2000.01 - 2010.12	132	450	163	245
		Local rice	2000.01 - 2010.04	124	377	146	205
Mali	Bamako	Imported rice	1993.02 - 2011.11	216	400	167	277
		Local rice	1993.02 - 2009.01	192	406	151	264
Chad	N'Djamena	Imported rice	2003.10 - 2011.11	98	618	350	434
		Local rice	2003.10 - 2011.11	98	588	259	388
Thailand	Bangkok	FOB price	1993.01 - 2012.02	230	432	54	175

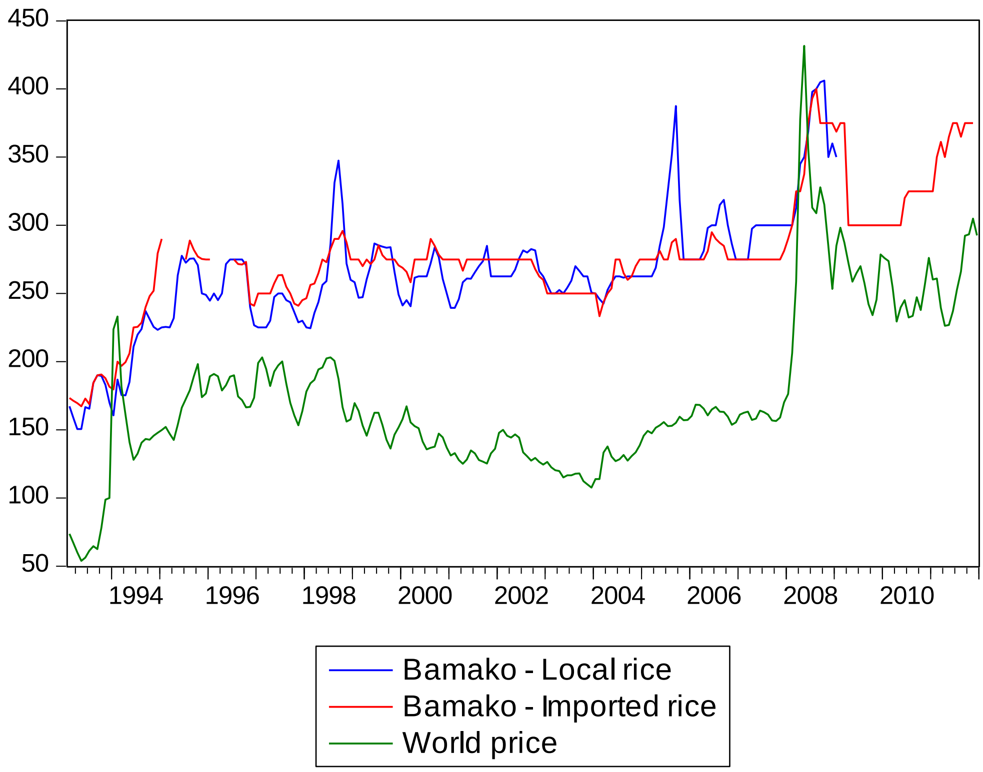
Note: Prices are expressed in CFA Francs /Kg

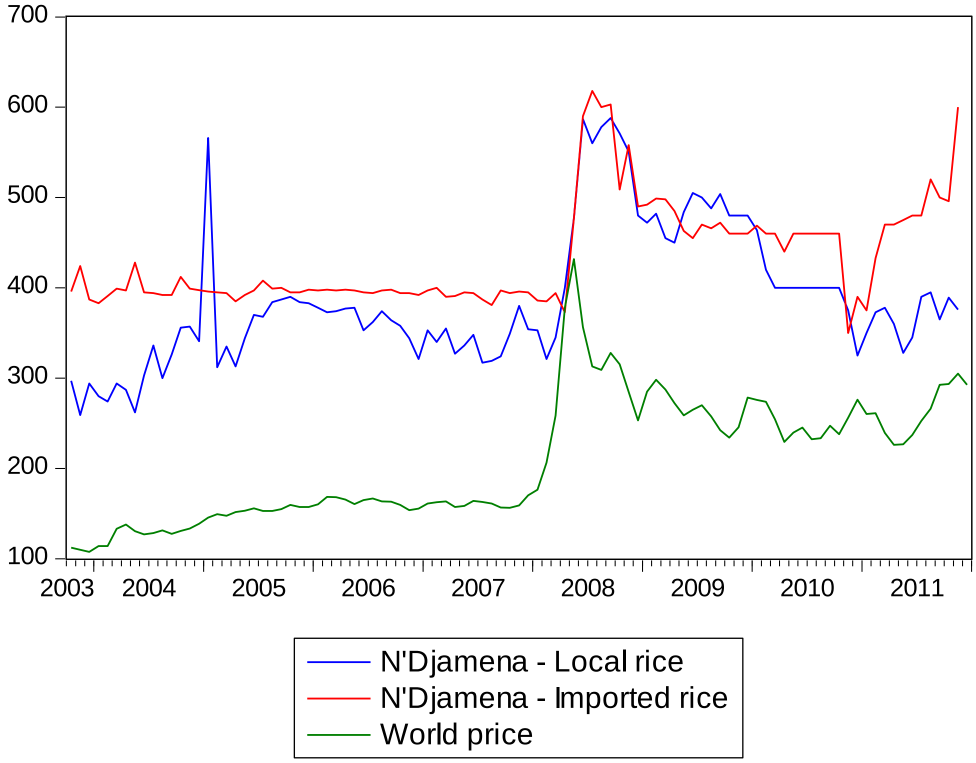
For each market, the time series of the domestic retail prices and the international price of rice are displayed in one figure, see Figure 1. For each country, domestic prices of local and imported rice are well above the level of the international price of rice excepted in early 2008 when the international price of rice sharply increased. The difference between the Thai export price and the domestic price of imported rice can be attributed to the costs of freight transport, insurance, importers and retailers margins, custom duties and handling charges.

Domestic prices of local rice are on average below the domestic prices of imported rice. The price discount between imported and local rice is higher in Dakar and N'Djamena than in Bamako. Local rice has to overcome a quality image problem in most West African markets and in such cases, a price discount may be needed to entice consumers. The situation is different in Mali where consumers prefer local rice making the price difference between local and imported rice lower than in Senegal and Chad. In Mali, prices of local rice are affected by seasonal fluctuations. The imported rice plays a role in stabilizing the price of local rice during the hunger season through increased imports at that period of the year thanks to temporary VAT exoneration.

Figure 1. Prices in CFA Francs per kilogram







The hypothesis that the price series are non-stationary is tested using the augmented Dickey-Fuller (ADF) test. ADF tests confirm the presence of a unit root in all price series. Stationarity could not be rejected for all the differenced series indicating that our price series are I(1) (Table 2).

Table 2. Results of ADF unit root tests

			Dakar			**Bamako**			**N'Djamena**			**World price**	
			ADF	Prob		ADF	Prob		ADF	Prob		ADF	Prob
PI	Level	[3]	-2,57	0,30	[3]	-3,25	0,08	[3]	-3,04	0,13	[2]	-1,94	0,31
	First diff,	[1]	-9,08	0,00	[1]	-6,79	0,00	[1]	-9,63	0,00	[1]	-7,49	0,00
PL	Level	[3]	-2,71	0,24	[3]	-3,15	0,10	[2]	-2,43	0,14			
	First diff,	[1]	-6,00	0,00	[1]	-3,71	0,00	[1]	-13,65	0,00			

PI : Imported price; PL: Local price ; [1]: Model without constant nor determinist trend, critical value = -1.95 ; [2]: Model with constant without determinist trend, critical value = -2.89 ; [3]: Model with constant and determinist trend, critical value = -3.45

4.2. Cointegration tests

Johansen cointegration tests indicate the existence of a single cointegration relationship among all pairs of prices at 10% level of confidence (Table 3). It indicates that there exists a long-run relationship between the domestic prices of local and imported rice and the world price of rice. In the short run, the domestic prices may drift apart, as shocks affecting the world price of rice may not be instantaneously transmitted to domestic prices of imported and local rice. However these divergences are transitory and the world price of rice and the domestic prices of rice move together in the long-run. The null hypothesis of cointegration is rejected in two cases at 5%

level. As the test statistics are close to the 5% critical values, we still proceed to the threshold cointegration tests for all the market pairs. Lag orders for cointegration tests are selected using Akaike Information Criteria (AIC), Schwartz Bayesian Criteria (SBC) and using partial autocorrelation function. The long term relationship was then estimated using ordinary least squares (Table A2)

Table 3. Johansen cointegration tests

		Hyp	Trace statistic	Critical value 5%	Maximum Eigen Value	Critical value 5%
Dakar	Imported rice	None	68,18***	15,49	67,26***	14,26
		At most 1	0,92	3,84	0,92	3,84
	Local rice	None	24,03*	25,87	17,72*	19,39
		At most 1	6,31	12,52	6,31	12,52
Bamako	Imported rice	None	25,49*	25,87	18,99*	19,39
		At most 1	6,49	12,52	6,49	12,52
	Local rice	None	50,64***	25,87	45,68***	19,39
		At most 1	4,97	12,52	4,96	12,52
N'Djamena	Imported rice	None	19,93**	15,49	16,94**	14,26
		At most 1	2,99	3,84	2,99	3,84
	Local rice	None *	31,22***	25,87	25,96***	19,39
		At most 1	5,26	12,52	5,26	12,52

* indicates significance at 10% level; ** at 5% level and *** significant at 1% level of confidence.

4.3. Testing for linearity

Hansen's tests are conducted for assessing the presence of regime-specific nonlinearities within the cointegration relationships of our market pairs. We follow Hansen's methodology and we alternatively test the null hypothesis of linearity against one threshold, the null of linearity against two thresholds and finally the null of one threshold against two. The first two tests are testing for linearity whereas the last one can be considered as a specification test. As discussed above, the tests reject H0 for large values of F_{ij}. Hansen's procedure estimates the thresholds θ and selects the delay parameter d. The results are presented in Table 4 and reject the null hypothesis of linearity for all pairs of prices. There are only two pairs for which the null of one threshold is rejected in favor of the two thresholds hypothesis. In those two cases, the two thresholds values are displayed.

Table 4. Hansen's tests of linearity

				Testing SETAR(1) against SETAR(2)[a]			Testing SETAR(1) against SETAR(3)[a]				Testing SETAR(2) against SETAR(3)[a]			
		p	d	F12	P.Value[b]	θ	F13	P.Value[b]	θ_1	θ_2	F23	P.Value[b]	θ_1	θ_2
Dakar	PI	4	3	30,92	0,01	18,68	73,70	0,00	-15,98	18,68	34,46	0,00	-15,98	18,68
	PL	6	4	36,81	0,01	5,39	67,85	0,00	-7,93	5,39	23,66	0,13		
Bamako	PI	3	1	22,19	0,00	9,80	26,38	0,13	-18,11	9,80	3,79	0,96		
	PL	3	3	34,05	0,00	10,55	76,75	0,00	-14,53	10,55	36,18	0,00	-14,53	10,55
N'Djamena	PI	3	2	22,14	0,02	-10,66	37,60	0,10	-23,03	-0,82	12,53	0,35		
	PL	3	3	29,34	0,02	12,24	52,45	0,02	12,24	33,74	17,66	0,12		

[a] Testing SETAR(1) against SETAR(2) H0 : Linearity HA: One threshold
Testing SETAR(1) against SETAR(3) H0 : Linearity HA: Two threshold
Testing SETAR(2) against SETAR(3) H0 : One threshold HA: Two threshold
[b] Bootstrapped P-value for 100 replications.
p : number of lags (the same number of lags is included in each regime)
d: delay of the transition variable
θ : the threshold value

Table 5 reports the results of the estimation of the SETAR models. The pairs Dakar imported rice-Thai export price and Bamako local rice-Thai export price are the only two pairs characterized by a three regimes autoregressive process. Regime 3 corresponds to large positive deviations that exceed the higher threshold while regime 1 corresponds to large negative errors that are below the lower threshold. In the two cases with three regimes, the thresholds are not symmetric around zero. In Dakar, the positive deviations from the long term equilibrium have to reach a higher level than the negative deviations before leading to a change in the domestic price of imported rice. The opposite is true in Bamako where the negative threshold is larger than the positive one. In the case of Bamako, the higher and the lower regimes contain approximately the same number of observations while in the Dakar case, the lower regime includes a larger number of observations than the higher regime.

Positive deviations from the long-run equilibrium are due to the decrease of the international price whereas negative deviations from the long-run equilibrium result from the world rice price increases.

The Figures A1 and A2 in appendix illustrate the timing of jumps among the regimes for respectively the imported rice in Dakar and the local rice of Bamako. In the case of Dakar, one third of the observations included in the upper regime take place between December 2008 and June 2009 corresponding to the decline in the international price of rice that followed the 2008 price spike. Even if the regime 2 is dominant, jumps between regimes are very common reflecting the high degree of instability of the imported price of rice in Dakar. Similarly jumps between regimes occur very often in the case of Bamako suggesting that large negative/positive deviations from the long run equilibrium are quickly corrected

Table 5. Estimates of the SETAR models

	Dakar - Imported rice						Dakar - Local rice			
	$\mu_{t-3} \leq -15.98$		$-15.98 < \mu_{t-3} \leq 18.68$		$\mu_{t-3} > 18.68$		$\mu_{t-4} \leq 5.39$		$\mu_{t-4} > 5.39$	
	ρ_3	s.e	ρ_2	s.e	ρ_1	s.e	ρ_2	s.e	ρ_1	s.e
Const.	-7.76*	(4.65)	-1.48	(1.78)	-23.91***	(6.44)	-1.78	(1.86)	-11.82***	(3.21)
μ_{t-1}	0.54***	(0.14)	1.21***	(0.12)	0.57***	(0.14)	0.64***	(0.13)	0.91***	(0.13)
μ_{t-2}	-0.03	(0.20)	-0.04	(0.16)	-0.15	(0.15)	0.12	(0.20)	-0.15	(0.14)
μ_{t-3}	0.13	(0.20)	-0.11	(0.22)	0.85***	(0.19)	0.19	(0.16)	-0.15	(0.16)
μ_{t-4}	-0.61***	-0,14	-0.11	(0.11)	-0.33*	(0.14)	-0.57***	(0.18)	0.79***	(0.20)
μ_{t-5}							-0.06	(0.14)	-0.73***	(0.17)
μ_{t-6}							0.03	(0.12)	0.62***	(0.15)
% of obs	22.66		61.72		15.62		61.86		38.14	

Standard error between brackets. * indicates significance at 10% level; ** at 5% level and *** significant at 1% level of confidence.

	Bamako - Imported rice				Bamako - Local rice					
	$\mu_{t-1} \leq 9.80$		$\mu_{t-1} > 9.80$		$\mu_{t-3} \leq -14.53$		$-14.53 < \mu_{t-3} \leq 10.55$		$\mu_{t-3} > 10.55$	
	ρ_2	s.e	ρ_1	s.e	ρ_3	s.e	ρ_2	s.e	ρ_1	s.e
Const.	-1.90	(1.20)	13.18***	(3.11)	2.17	(3.46)	0.52	(1.21)	0.18	(3.356)
μ_{t-1}	0.91***	(0.09)	0.61***	(0.15)	0.94***	(0.12)	1.79***	(0.14)	0.67***	(0.10)
μ_{t-2}	-0.24*	(0.12)	-0.22	(0.15)	-0.17	(0.17)	-0.90***	(0.24)	-0.03	(0.13)
μ_{t-3}	0.11	(0.09)	-0.06	(0.11)	-0.04	(0.15)	0.25	(0.23)	-0.14	(0.11)
% of obs	62.44		37.56		25.93		48.68		25.4	

Standard error between brackets. * indicates significance at 10% level; ** at 5% level and *** significant at 1% level of confidence.

	N'Djamena - Imported price				N'Djamena - Local rice			
	$\mu_{t-2} \leq -10.66$		$\mu_{t-2} > -10.66$		$\mu_{t-3} \leq 12.24$		$\mu_{t-3} > 12.24$	
	ρ_2	s.e	ρ_1	s.e	ρ_2	s.e	ρ_1	s.e
Const.	-16.82	(10.28)	13.92	(8.45)	-8.08	(5.98)	18.79	(12.04)
μ_{t-1}	1.06***	(0.26)	0.09	(0.11)	0.77***	(0.12)	-0.08	(0.16)
μ_{t-2}	-0.73*	(0.31)	0.04	(0.12)	-0.03	(0.12)	0.78***	(0.22)
μ_{t-3}	-0.04	(0.16)	0.13	(0.14)	-0.26	(0.15)	-0.24	(0.17)
% of obs	50.53		49.47		65.26		34.74	

Standard error between brackets. * indicates significance at 10% level; ** at 5% level and *** significant at 1% level of confidence.

4.4. Threshold error correction models

As Hansen's test suggests that our market pairs follow a nonlinear relationship, we use a threshold error correction model to estimate the speed at which domestic prices returns to equilibrium after a deviation has occurred. The estimated values of the error correction terms of each regime and the Wald tests of equality of the coefficients are presented in Table 6.

Model (5) and (7) allow all the parameters of the model to switch between regimes. We could as well use a more parsimonious specification where only the error correction terms vary with the regimes. Hence, we tested the equality of the error correction terms across regimes (Table

6) as well as the equality of the short and long-run parameters across regimes (not reported here). According to these results, we estimated models that allow asymmetries of every parameter or of only the ECT term. The estimated model including the imported rice in Dakar is the only one where the Wald tests reject by a majority the equality of the short and long-run parameters across regimes. Hence, only the model of the imported rice in Dakar allows asymmetries for all the parameters to be captured.

Table 6. Results of asymmetric error correction models

		Error correction terms			Wald tests of equality of the coefficients		
		β_1	β_2	β_3	β1 = β2 (=β3) = 0	β1 = β2 (= β3)	β1 = β3
Dakar	Imported rice	-0.90***	-0.05	-0.16**	16.94	13.26	23.71
		(0.13)	(0.16)	(0.07)	(0.00)	(0.00)	(0.00)
	Local rice	-0.18	-0.36*		1.70	1.71	
		(0.13)	(0.20)		(0.18)	(0.19)	
Bamako	Imported rice	-0.11**	-0.14		6.40	0.07	
		(0.05)	(0.1)		(0.00)	(0.79)	
	Local rice	-0.19***	0.07	-0.54***	13.95	11.91	8.76
		(0.07)	(0.08)	(0.10)	(0.00)	(0.00)	(0.00)
N'Djamena	Imported rice	-0.39***	-0.29		4.28	0.49	
		(0.13)	(0.18)		(0.02)	(0.49)	
	Local rice	-0.21	-0.56***		8.08	1.82	
		(0.13)	(0.19)		(0.00)	(0.18)	

White Heteroscedasticity-consistent Standard error between brackets. * indicates significance at 10% level; ** at 5% level and *** significant at 1% level of confidence. [a] : Entries in this three columns are the sample F statistics for the null hypothesis of equality of the coefficients. Significance levels are in parentheses below.

The Wald tests of equality of the error correction terms (Table 6, columns 4 to 6) do not reject the null hypothesis of linear adjustment in four cases out of six: Dakar (local rice), Bamako (imported rice) and N'Djamena (imported and local rice).

In the case of the local rice in Dakar, the Wald test even rejects the hypothesis of cointegration. This result is not surprising considering that the Johansen's test was not significant at 5% level. The price of local rice in Dakar is not linked with the world price of rice by a long run relationship. This can be attributed to the small quantities of local rice marketed in Dakar and to the low awareness of urban consumers that quality local rice even exists (Rizotto and Demont, 2010). Many Senegalese still consider local rice as inferior in quality to imported rice suggesting that there is very little substitutability between imported and local rice. In addition, local rice is available only seasonally; local rice is rarely available in domestic markets from November to January (USAID, 2009c).

In the cases of Bamako (imported rice) and N'Djamena (imported and local rice), the adjustment process between the domestics prices and the world market appears to be linear (Table 6, column 5). It means that a constant proportion of the error is corrected each month regardless of the size of this deviation. Positive and negative deviations from the long-run equilibrium are transmitted to the same extent and at the same speed. Table 7 provides the estimation of the error correction terms in the three cases in which threshold cointegration is rejected. The estimated error correction models suggest that the adjustment processes are relatively fast in N'Djamena with about 33 percent of divergence from the long run equilibrium being corrected each month in the case of the imported rice and 42 percent in the case of the local rice. The adjustment is slower in Mali; the price of imported rice in Bamako will fully adjust to changes in the international price in a period equal to almost 8 months. Such a low rate of adjustment can be attributed to policies including temporary VAT/customs tariff exemptions on rice imports and national security stock of rice management implemented by the government to ensure food security.

Table 7. Results of linear cointegration models

				Speed of adjustment			
				Linear adjustment	Non-linear adjustment		
Location	Commodity	Long term relationship?	Asymmetric transmission?		Down	Middle	Up
Senegal - Dakar	Imported rice	Yes	Yes		-0.90***	-0.05	-0.16***
Senegal - Dakar	Local rice	No	No				
Mali - Bamako	Imported rice	Yes	Yes	-0.13***			
Mali - Bamako	Local rice	Yes	No		-0.19***	0.07	-0.54***
Chad - N'Djamena	Imported rice	Yes	No	-0.33***			
Chad - N'Djamena	Local rice	Yes	No	-0.42***			

Note: * indicates significance at 10% level; ** at 5% level and *** significant at 1% level of confidence.

Asymmetry is not rejected for the pairs of markets characterized by three regimes of adjustment. The Wald tests reject the hypothese of linear and symmetric adjustment in two cases: Dakar (imported rice) and Bamako (local rice). The imported rice and the local rice are the main staple food respectively in Senegal and Mali. The prices of these two staple cereals appear to be affected by large fixed transactions costs. Price deviations contained in the interval [θ1, θ2] are too small compared to the adjustment costs that they will not lead to a price adjustment. Indeed the coefficients of the error correction terms are not significant in regime 2 in both cases.

In the case of Bamako, there appears to be adjustment both in periods of large positive and negative change from the long term equilibrium. The speed of adjustment is larger in the upper regime. The price of local rice is Bamako will return more quickly to the value consistent with the long-run relationship to the world price in case of positive deviations than in case of negative deviations from the long term equilibrium. The positive deviations from the long term equilibrium have to reach a level of 10.55 CFA Francs per kilo before leading to a change in the domestic price of local rice.

Positive deviations from the long-run equilibrium are caused by a decrease in the world price of rice. Hence, the adjustment occurs more rapidly when the domestic price of local rice drift too far away from the long term equilibrium following a drop in the world price of rice. Conversely, the domestic price of local rice increased slowly in response to a world price spike suggesting that price of local rice in Bamako cannot increase excessively. Indeed, the Government of Mali intervenes regularly on the market to prevent high increase in the domestic prices of local rice through temporary exemption on customs tariffs and VAT. The government of Mali exempted 40 000 metric tons (MT) of rice from VAT in 2002, 201,194 MT in 2005, 5,504 MT in 2007 and 105,789 MT in 2008 (USAID, 2009b). These exemptions may discourage private actors to invest in the domestic market channel as they provide regular opportunities for wholesalers to have access to large quantities of cheap imported rice. In this way, exemptions have a strong effect on the prices of local rice. This is worth noting that the surges in domestic prices of local rice are not necessarily related to increase in the world price. Indeed in 1998 and 2005, the price of local rice increased due to a tight supply situation at the regional level rather than following the world price trend. Whatever the causes may be, government interventions allowing massive imports of cheap rice prevent the price of local rice to increase excessively compared to the world price of rice.

For Dakar, error correction terms are significant in the outer regimes but the coefficient is larger in the lower regime. Negative deviations from the long term equilibrium have to reach almost 16 CFA Francs per kilo before leading to a change in the domestic price of imported rice. Large negative deviations result from large increases in the world price of rice. It suggests that the price of imported rice in Dakar adjust very well to changes in the international price when the world price increases. This result is consistent with the high degree of dependency on rice imports in Dakar. The domestic price of imported rice adjusts well to an increase in the world price of rice as consumers are reticent to substitute rice with other grains. The asymmetric adjustment is likely to reflect a situation of market power in the distribution chain or high fixed costs in the distribution industry.

5. Conclusion

Our results indicate that the world price of rice and the domestic prices of imported and local rice in Senegal, Mali and Chad are integrated in the long-run, with the exception of the local rice in Dakar. The changes affecting the world price of rice do not have any impact on the price of local rice in Dakar. This may be due to the low quality of local rice in comparison to the imported rice. Structurally, the market for local rice is essentially a thin residual market. Consumers may be unwilling to substitute from imported rice to local rice. Since 2008, the Senegalese government has launched national programs to boost local rice production in order to achieve complete food self-sufficiency by 2015. Achieving rice self-sufficiency requires greater recognition that the rice market is not driven exclusively by price. Local rice must improve its awareness among consumers and make significant efforts in improving appearance, packaging and cleanliness in order to compete more effectively with imported rice.

We find that the domestic price of imported rice in Bamako and the domestic prices of imported and local rice in N'Djamena are integrated with the world price of rice. In those three cases, domestic prices are affected in similar ways by changes in the world price regardless of the size of the deviation. For the Chadian rice markets, the adjustment process is fast; rice prices in Ndjamena adjust fully to price changes in the international market in two or three months. Conversely, it would take about height months for prices of imported rice in Bamako to fully adjust to a change in the international rice price, reflecting the policies implemented by the government to ensure food security.

The price of local rice in Bamako responds asymmetrically to large changes from the long term equilibrium. Our results provide evidence that increases in the world price are incompletely and slowly passed-through to the domestic market, as compared to decreases. The negative asymmetric price transmission can be attributed to governmental interventions intended to protect consumers. The government intervenes regularly through tax exemptions and food security stock management as to prevent local price to increase excessively. If this policy favors consumers, it may discourage private actors to invest in the domestic market channel. The relationship between the world price of rice and the domestic price of local rice in Bamako may change in the coming years under the influence of the Rice Initiative launched in 2008 by the Malian Government. This initiative aims at boosting rice production through various means including subsidies for rice production so as to make the country a net exporter of rice.

Small changes in the world price of rice do not affect the price of imported rice in Dakar. High transaction costs of importing rice and moving it from the port to consumption centers are likely to exist. Price deviations have to exceed a certain threshold before leading to a change in the domestic price of imported rice. The price of imported rice in Dakar is more responsive to the world price of rice spike than to the world price drop. This positive asymmetric price transmission is likely to reflect a situation of market power in the import chain.

References

Araujo-Bonjean, C., & Brun, J-F. (2010). Price Transmission in the Cocoa-Chocolate Chain. Working Papers 201003, CERDI.

Balasubramanian, V., Sie, M., Hijmans, R. J., & Otsuka, K. (2007). Increasing rice production in sub-Saharan Africa: Challenges and opportunities. Advances in Agronomy, 94, 55-133.

Balke, N. S., & Fomby, T. B. (1997). Threshold cointegration. International Economic Review, 38(3), 627-45.

Badolo, F. (2012). Chocs de prix internationaux et transmission : cas du marché de riz au Burkina Faso. L'Actualité Économique, 88(3).

Baffes, J., & Gardner, B. (2003). The transmission of world commodity prices to domestic markets under policy reforms in developing countries. Journal of Policy Reform, 6(3), 159-180.

Baris, P., Zaslavsky, J., & Perrin, S. (2005). La filière riz au Mali : compétitivité et perspectives de marché. Document de Travail, 5. Agence Française de Développement.

Ben Salem, M., & Perraudin, C. (2001). Tests de linéarité, spécification et estimation de modèles à seuil : une analyse comparée des méthodes de Tsay et de Hansen. Economie & prévision, 148, 157-176.

Bricas, N., Thirion, M. C., & Zougrana, B. (2009). Bassins de production et de consommation des cultures vivrières en Afrique de l'Ouest et du Centre. AFD, Cirad, Cilss, IFAD.

Conforti, P. (2004). Price transmission in selected agricultural markets. Commodities and Trade Policy Research Paper No. 7. Rome, Italy: Food and Agriculture Organization.

Davies, R. B. (1987). Hypothesis testing when a nuisance parameter is present only under the alternative. Biometrika, 74, 33-43.

Enders, W., & Siklos, P. L. (2001). Cointegration and Threshold Adjustment. Journal of Business and Economics Statistics, 19(2), 166-176.

FAO (2009). The 2007–2008 price episode: further insights on causes and characteristics. Technical Brief No. 1. Rome, Italy: Food and Agriculture Organization.

FAO (2011a). Why has Africa become a net food importer? Explaining Africa agricultural and food trade deficits. Rome, Italy: Food and Agriculture Organization.

FAO (2011b). The 2007-08 Rice Price Crisis. Policy brief No. 13. Rome, Italy: Food and Agriculture Organization.

FAOSTAT (2013). Rome, Italy: Food and Agriculture Organization. Available from: http://faostat.fao.org/

Gilbert, C. L. (2010). Food Prices in Six Developing Countries and the Grains Price Spike. University of Trento, Italy.

Goodwin, B. K., & Harper, D. (2000). Price Transmission, Threshold Behavior, and Asymmetric Adjustment in the U.S. Pork Sector. Journal of Agricultural and Applied Economics, 32, 543-553.

Goodwin, B. K., & Piggott, N. E. (2001). Spatial Market Integration in the Presence of Threshold Effects. American Journal of Agricultural Economics, 83(2), 302-317

Hansen, B. E. (1997). Inference in TAR model. Studies in nonlinear dynamics and econometrics, 2(1), 1-14.

Hansen, B. E. (1999). Testing for linearity. Journal of Economic Surveys, 13(5), 551-576.

Janin, P. (2009). Les émeutes de la faim : une lecture (géopolitique) du changement (social). Politique étrangère, Dunod, Institut Français des Relations internationales, pp.251-263.

Mendez del Villar, P., Bauer, J. M., Maiga, A., & Laouali, I. (2010). Crise rizicole, évolution des marchés et sécurité alimentaire en Afrique de l'Ouest. CILSS, CIRAD, FAO, FEWS NET, WFP.

Meuriot, V. (2012). Une analyse comparative de la transmission des prix pour l'orientation des politiques publiques : le cas du riz au Sénégal et au Mali. Document de recherche, LAMETA.

Meyer, J., & von Cramon-Taubadel, S. (2004). Asymmetric Price transmission: a survey. Journal of Agricultural Economics, 55(3), 581-611.

Rapsomanikis, G. (2011). Price Transmission and Volatility Spillovers in Food Markets of Developing Countries. Safeguarding food security in volatile global markets (chap 8, 165- 179). Rome, Italy: Food and Agriculture Organization.

Rizzotto, A. C. & Demont, M. (2010). Extending reach to strengthen value chains: Increasing consumer awareness of quality Senegal River valley rice. Africa rice center.

Stigler, M., & Tortora, P. (2011). Food crisis: did prices rise faster than they fell? Research Topics in Agricultural and Applied Economics, 2, 19-30.

Tong, H. (1983). Threshold Models in Non-linear Time Series Analysis. New York: Springer-Verlag.

USAID (2009a). Global Food Security Response: West Africa Rice Value Chain Analysis. Report No. 161. Washington, DC: United States Agency for International Development.

USAID (2009b). Global food security response case study: Mali. Washington, DC: United States Agency for International Development.

USAID (2009c). Global food security response: Senegal rice study. Washington, DC: United States Agency for International Development.

Annex

Table A1. Area Harvested, Production, Imports and Consumption

	Area Harvested (1000 HA)			Milled Production (1000 MT)			Imports (1000 MT)			Consumption (1000 MT)		
	Chad	**Mali**	**Senegal**	**Chad**	**Mali**	**Senegal**	**Chad**	**Mali**	**Senegal**	**Chad**	**Mali**	**Senegal**
2001	51	350	95	47	492	140	2	39	735	49	531	850
2002	90	365	88	87	637	159	0	76	916	87	713	890
2003	105	370	76	92	462	112	0	175	875	92	637	930
2004	95	385	87	86	620	150	0	156	825	86	776	980
2005	95	370	83	62	475	151	19	130	750	81	605	982
2006	110	390	95	90	624	181	14	125	660	104	749	981
2007	80	414	97	70	684	144	15	105	675	85	789	950
2008	80	377	99	67	703	118	15	100	820	82	803	940
2009	111	433	125	104	860	277	16	100	683	120	945	980
2010	133	580	131	79	1027	345	20	120	690	99	1 075	1055
2011	154	686	147	125	1500	408	10	80	775	135	1400	1130
2012	165	500	110	103	1132	299	20	150	1150	123	1420	1250

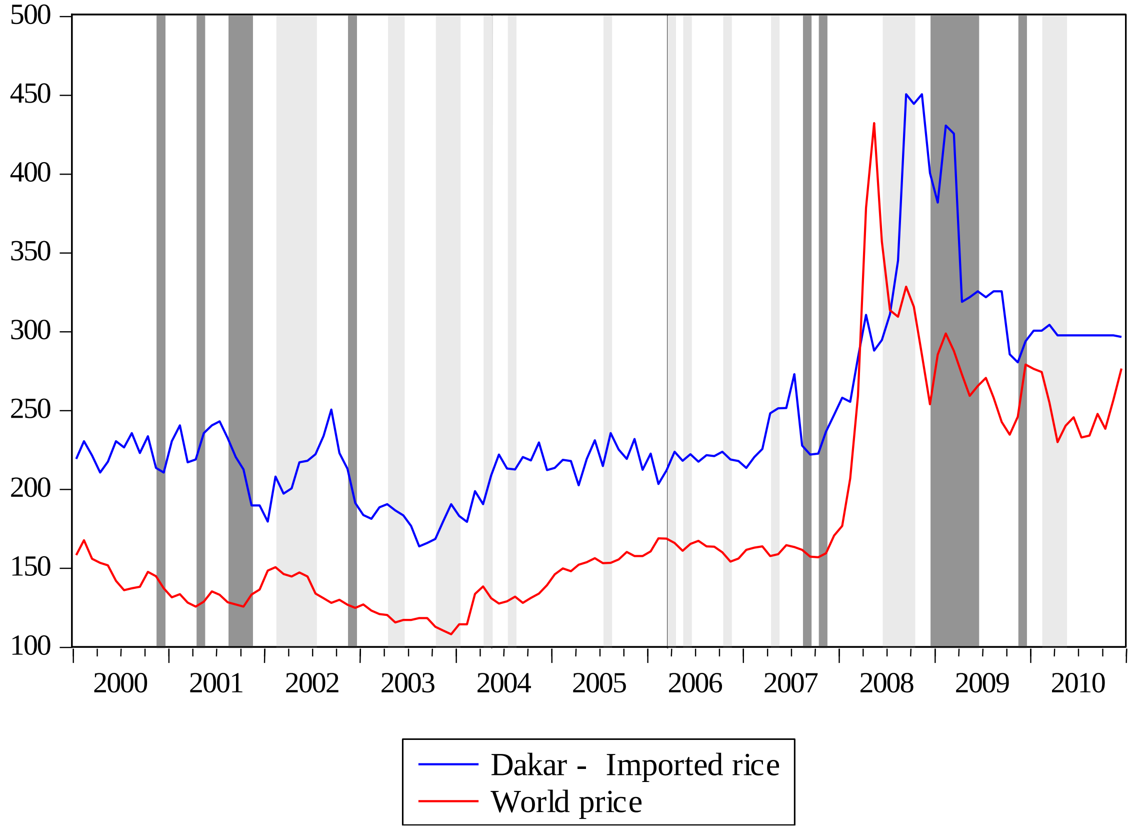
Source : USDA (http://www.fas.usda.gov/psdonline/)

Table A2. Estimation of the long-term relationship: $P^D_t = \alpha_0 + \alpha_1 P^W_t + \alpha_2 T_t + \mu t$

		α0	α1	α2	Adj R²	SBC	AIC
Dakar	PI	108.44 (13.1)	0.77*** (17.5)		0.70	9.86	9.82
	PL	64.8 (9.21)	0.50*** (13.24)	0.37*** (5.55)	0.84	8.78	8.74
Bamako	PI	177.05 (38.72)	0.37*** (12.15)	0.30*** (10.65)	0.74	9.08	9.03
	PL	157.76 (26.72)	0.37*** (10.21)	0.49*** (14.7)	0.71	9.28	9.23
N'Djamena	PI	308 (24.33)	0.61*** (10.46)		0.53	10.25	10.20
	PL	304.85 (8.20)	1.02*** (8.31)	-0.72*** (-2.43)	0.52	10.88	10.8

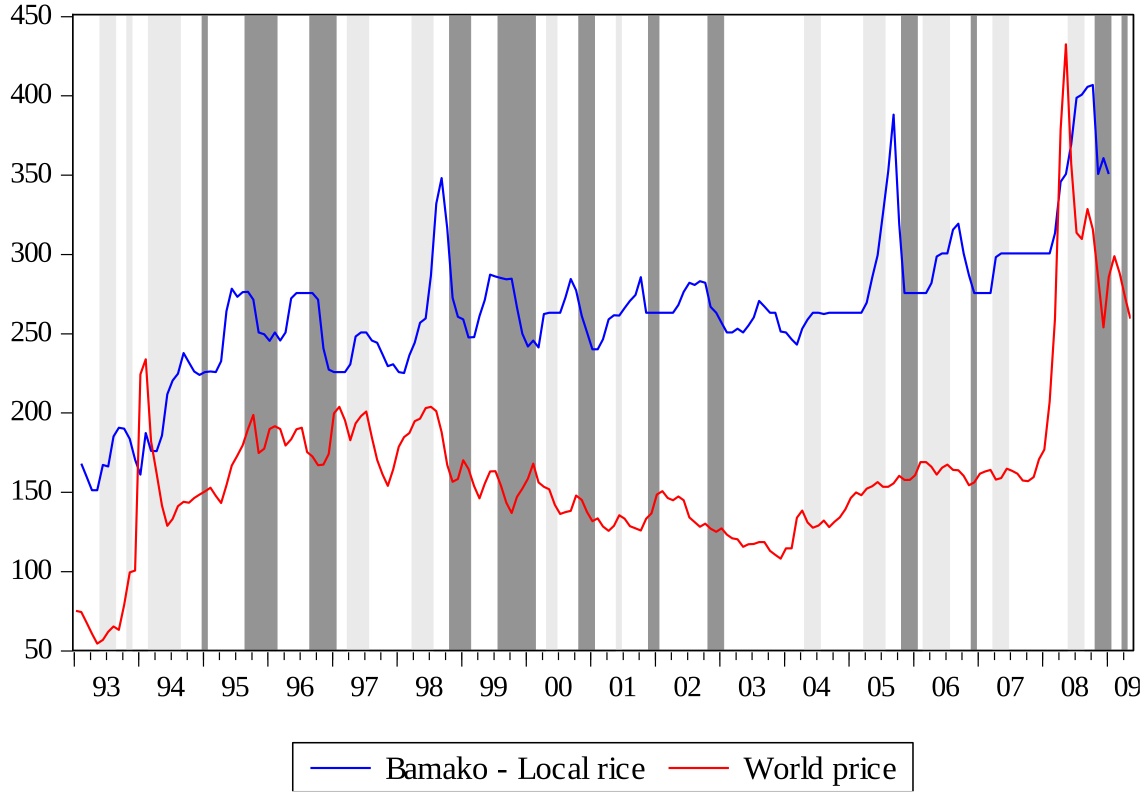
Where T is the time trend and is included only when the variable is significant; PI : Imported price; PL: Local price; AIC: Akaike criterion; SBC: Schwartz criterion; t-Statistic between brackets. * indicates significance at 10% level; ** at 5% level and *** significant at 1% level of confidence.

Figure A1. Timing of regime switching - Dakar imported rice



The period corresponding to regime 3 are shaded in dark grey whereas the periods corresponding to regime 1 are in light grey.

Figure A2. Timing of regime switching - Bamako local rice



The period corresponding to regime 3 are shaded in dark grey whereas the periods corresponding to regime 1 are in light grey.