Rice Prices Shocks Transmission from International to Domestic Markets: An Evidence from Bamako and Kayes Rice Markets in Mali

ABSTRACT:
This study assessed the transmission of international price shocks to domestic prices in the Bamako and Kayes markets. Threshold Autoregressive Model developed by Balke and Fomby (1997) was used in the study. The empirical analysis used monthly price data from Bamako and Kayes markets over the period January 2006 to September 2016. The results of descriptive statistics showed that during the period 2006-2016, the average price of imported rice were 313 CFA francs in Bamako and 297 CFA francs in Kayes, respectively. The average price for local rice were 328 CFA francs in Bamako and 387 CFA francs in Kayes. The empirical results showed that local rice price in Kayes as well as imported rice price in Bamako responded asymmetrically to international price changes. International price increases were more rapidly transmissible to domestic prices than its decreases. Better regulation of rice markets and more road infrastructure would limit the power of commercial intermediaries and contribute to a better functioning of market structures.

***Keywords*: International shocks, asymmetric adjustment, TAR model, Rice, Mali.**

1. INTRODUCTION

The 2007-08 food crisis with its extensive consequences in sub-Saharan Africa, have generated interest in research on the transmission of food prices. International commodity prices such as maize, rice and wheat have increased significantly [1]. Between November 2007 and May 2008, rice prices have tripled. Maize prices have doubled between July 2007 and June 2008, from US$150 to US$300 per ton. Over the same period, prices for dairy products and palm oil have increased by 44% [2]. In addition, comparing the 27 years (1980-2006) prior to the crisis with the 4 years (2007-2010) following it, shows an increase in international monthly prices of 52% for maize, 87% for rice and 102% for wheat [3]. Several reasons were advanced for this price rising, including export restraint policies by some emerging countries, the depreciation of the US dollar against the euro, and the rise in oil prices[1] [4, 5].

Rice is also one of the main sources of food for Malian populations [2]. Several consumers prefer it to other cereals because of the minimal time it takes to be cooked and the quality of its cooking [6]. Since the consumption of rice in Mali exceeds the capacity of local production (about 70%), the country becomes increasingly dependent on food imports [7]. However, as indicated by [8], the transmission of higher international prices to domestic markets in developing countries can have a high impact on farmers as well as low-income consumers. Low-income consumers spend a large part of their income on the consumption of commodities, making them more vulnerable to volatile food prices [9]. As a result, an increase in the international price of foodstuffs could affect Mali's domestic markets.

Several scientific studies show that the effects of the 2007-08 price rising are not identical in developing countries. In some countries, the effects are less significant than in others. This situation reflects an asymmetric transmission of prices. Several factors may be responsible for that, including State intervention mechanisms, antiquated infrastructure of transport and communication, contractual agreements between economic agents and the complexity of marketing channels. These asymmetry factors are likely to reduce producer incomes and contribute to agricultural price volatility by exposing domestic markets to shocks [10, 1].

The issue of price transmission has been the subject of considerable literature due to the influence of price on producer and consumer behavior. Indeed, prices encourage economic agents to change their production and consumption because they serve to give signals on what must be produced and consumed. The empirical results are mixed on the degree of transmission of international price shocks at domestic prices. For instance, based on annual data from 22 developing countries covering the period 1961-1987, [11] indicated that the change in international prices is not transmitted to prices paid to producers. Similarly, by studying the integration of agricultural markets in Iran after its entry into the World Trade Organization, [12] concluded that domestic markets are not integrated into international markets in the long term. Finally, by examining the mechanisms for transmitting changes in international rice prices to domestic prices in three African countries, [13] concluded that the imported rice price in Dakar and the local rice price in Bamako respond asymmetrically to changes in international prices. For the author, these results are explained by the market power of commercial intermediaries, high transportation costs and government intervention mechanisms.

On the other hand, [14] on the basis of price data from 58 developing countries showed an almost perfect transmission of changes in international prices at domestic prices. A study on the impact of changes in international prices on consumer prices for staple foods such as wheat, rice, maize and sorghum in 60 developing countries was conducted by [15]. Their

[1] The price of oil rose from US$30 per barrel in 2003 to more than US$140 per barrel in July 2008.

results show that consumer markets in developing countries are co-integrated into international markets. Similarly, in Burkina Faso, [16] showed that rice prices in the markets of Sankaryaré and Dori are perfectly integrated with the international price. For the author, increases in the international price are more rapidly transmitted to domestic prices than its decreases. Also, it is shown that international food price indexes are perfectly integrated with Thailand's consumer price indexes [17]. In addition, based on data from 147 countries, [1] showed that there is a strong transmission of international prices to local prices, especially in low-income countries. Finally, in a recent study based on developing countries, [18] showed that the transmission of international prices to domestic prices is statically significant for a quarter (1/4) of maize markets, half (1/2) of rice markets and for all wheat markets studied.

Overall, several studies address the issue of price transmission, but few focus on the specific case of Mali. This paper fills this gap by assessing the adjustment speed of domestic rice prices (local and imported) following a change in the international price. Our analysis focuses on the markets of Bamako and Kayes using a methodology based on the autoregressive threshold model (TAR) developed by [19]. Our data are monthly and cover the period from January 2006 to September 2016. The empirical results show that the local rice price in Kayes and imported rice price in Bamako respond asymmetrically to international price changes. In other words, increases in international prices are transmitted more quickly to domestic markets than its decreases.

The rest of the article is organized as follows. Section 2 presents the study methodology and data. Empirical results are presented and discussed in Section 3 and Section 4 concludes.

2. METHODOLOGY AND DATA

2.1. DATA

The data came from FAO statistics and covered the period from January 2006 to September 2016. These were the monthly rice prices (imported and local) from the Bamako and Kayes markets. We look at these two cities because the prices that were formed there were supposed to converge towards the national average and therefore be representative. We considered the best approximation of the world price, the export price of Thai rice as Thailand is the world's largest exporter of rice [20]. To account for inflation, all prices were expressed in CFA francs and adjusted by a consumer price index. For estimation, we used the logarithm of prices. The coefficients were interpreted as elasticities[2].

2.2. Econometric Estimate Strategy

First, we will apply Granger's standard unitary root tests, cointegration tests and causal tests [21]. Next, to test the asymmetric transmission hypothesis, we will apply tests based on the autoregressive threshold model.

2.2.1. Standard tests for stationarity and integration

Several unit root tests[3] exist to test the non-stationarity of a time series. For this analysis, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are applied. Like [17], we then test the hypothesis of non-integration of price series using the Engle-Granger method [22] and the Johansen method [23]. To test the non-compartmentalization hypothesis of the series using the Engle-Granger method, we start from the long-term equilibrium relationship between the international price of rice and domestic prices of imported rice.

The long term relationship is given by:

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[2] http://www.fao.org/giews/pricetool/

[3] Hamilton (1994): Mignon and Lardic (2002).

$$P_t^D = \alpha_0 + \alpha_1 P_t^W + \mu_t \qquad \textbf{(1)}$$

Where P_t^D denotes the price on the domestic market and P_t^W the price of rice on the world market. These different prices are expressed in CFA francs. μ_t is the constant random variance error term. It captures the effect of unobservable variables such as transaction costs, intervention policies. If μ_t is stationary, the two prices P_t^D and P_t^W are co integrated, which implies that they are bound by a stable long term equilibrium relationship. The coefficient α_1 in equation (1) represents the long term transmission elasticity. It measures the proportion of transmitting variations P_t^W to P_t^D.

To test the null hypothesis of non-cointegration, the Engle-Granger method applied to the residue from equation (1) is defined as follows:

$$\Delta\mu_t = \rho\mu_{t-1} + \varepsilon_t \qquad \textbf{(2)}$$

Where ρ is the convergence speed and ε_t a white noise. The standard integration tests, namely the Augmented Dickey-Fuller and the Phillips-Perron test are performed on the equation (2). The hypothesis of non-cointegration may be rejected if the residues ε_t are stationary and null average. We also run the Johansen integration test. If the tests negate the non-cointegration hypothesis, an error corrected model is estimated to examine the short term dynamics. This model is presented in the following form: μ_t

$$\Delta P_t^D = \gamma\mu_{t-1} + \sum_{k=1}^{p} \theta_k \Delta P_{t-k}^W + \sum_{k=1}^{p} \rho_k \Delta P_{t-k}^D + \upsilon_t \qquad \textbf{(3)}$$

Where γ is the adjustment speed of P_t^D and θ_k represents short term transmission elasticities (short term dynamics).

2.2.2. Modelling Asymmetric Transmission

The hypothesis that international price increases transmit more quickly to domestic markets than its decreases is tested using an autoregressive threshold model, namely:

$$\Delta\mu_t = I_t \rho_1 \mu_{t-1} + (1 - I_t)\rho_2 \mu_{t-1} + \psi_t \qquad \textbf{(4)}$$

Where μ_t is the residue of the relationship (1); ρ_1 and ρ_2 are respectively positive and negative values of the residue, first introduced by [25] to account for asymmetric adjustments. According to these authors, the condition for stationary status is μ_t **-2 < (** ρ_1 **,** ρ_2 **)** < 0. **I** is an indicator function defined as:

$$\mathrm{I_t} = \begin{cases} 1 \text{ si } \mu_{t-1} \geq 0 \\ 0 \text{ si } \mu_{t-1} < 0 \end{cases} \qquad \textbf{(5)}$$

The necessary and sufficient conditions of stationarity μ_t are $\rho_1 < 0$, $\rho_2 < 0$ and (1 ρ_1 +) (1+ ρ_2) < 1. The long term equilibrium is given by $\mu_{t-1} = 0$. If $\mu_{t-1} \succ 0$, this means that a decrease in international price leads to a positive deviation from the long term balance, in this case the adjustment is equal to $\rho_1\mu_{t-1}$. If $\mu_{t-1} \prec 0$ an increase in the international price results in a negative deviation from equilibrium, in this case the adjustment is equal to $\rho_2\mu_{t-1}$. On the other hand, if $\rho_1 < \rho_2$, then positive deviations are abated faster than negative deviations.

The threshold may not be zero, in this case equation (5) becomes:

$$\mathrm{I_t} = \begin{cases} 1 \text{ si } \mu_{t-1} \geq \tau \\ 0 \text{ si } \mu_{t-1} < \tau \end{cases} \qquad \textbf{(6)}$$

Where τ is the value of the threshold that is endogenously estimated. To consider the dynamic adjustment effects, [22] showed that equation (4) can be modified by adding lags of μ_t. Indeed, equation (4) is not sufficient to capture the dynamic adjustment $\Delta\mu_t$ of its long term equilibrium value. The modified equation (4) is as follows:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1-I_t)\rho_2\mu_{t-1} + \sum_{i=1}^{p-1}\gamma_i\Delta\mu_{t-1} + \varepsilon_t \qquad \textbf{(7)}$$

Before estimating equation (7), it is necessary to ensure that there is no autocorrelation of residues and that the appropriate number of lags is chosen. Residue autocorrelation is tested using Ljung-Box tests and the number of lags is determined from the Akaike Information Criteria [24]. The integration test in the TAR model is based on coefficients ρ_1 and ρ_2. If the price integration hypothesis is verified, the coefficients ρ_1 and ρ_2 are negative. Enders and Siklos [26] use two tests: *t-Max* (the largest of the two individual statistics) and *t-Min* (the smallest) to test the hypothesis that the coefficients are significantly negative and *F-test* to test the hypothesis that they are jointly different from zero. The critical values of these tests are given in the article by [26].
To estimate the value of the threshold in equation (7), we use the Chan method. The author showed that it is possible to obtain a good threshold estimator from the minimization of the sum of the residue squares. The procedure is to estimate the residues of equation (2), which are then sorted in ascending order, 15% of the highest values and 15% of the lowest values are removed and the remaining 70% of the values are considered potential thresholds. Equation (7) is estimated for each potential threshold. The estimated value of the threshold τ from the minimization of the sum of the square residue is retained. Equations (1), (4) and (6) allow for the estimation of an asymmetric error correction model as follows:

$$\Delta P_t^D = \omega + \rho_{1.1}I_t\mu_{t-1} + \rho_{1.2}(1-I_t)\mu_{t-1} + \sum_{k=1}^{P}\delta_k\Delta P_{t-k}^W + \sum_{k=1}^{P}\beta_k\Delta P_{t-k}^D + \eta_t \qquad \textbf{(8)}$$

Where $\rho_{1.1}$ and $\rho_{1.2}$ are respectively adjustment coefficients for positive and negative chocs.

3. RESULTS AND DISCUSSION

3.1. Descriptive statistics

Table 1: Descriptive statistics of rice prices in Mali

Markets	Types of prices	Period of study	Obs.	Coef. Var.	Min	Max	Coef. Corr.	Moy.
Bamako	Imported Rice	2006.01-2016.09	129	0.11	240	375	0.28	313.14
	Local Rice	2006.01-2016.09	129	0.12	250	425	0.18	327.75
Kayes	Imported Rice	2006.01-2016.09	129	0.09	245	380	0.28	296.43
	Local Rice	2006.01-2016.09	129	0.13	290	450	0.01	**387.05**
Thailand	Bangkok	2006.01-2016.09	129	0.30	124.97	458.08	----	227.67

Prices are in CFA Francs/kg

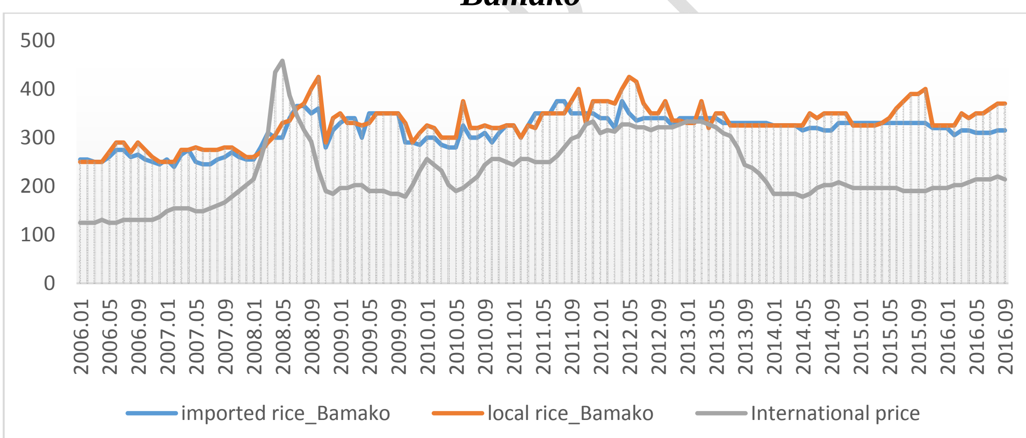
In the analysis of Table 1, we observe that the price level on the Kayes local rice market is relatively higher than that of Bamako during the period 2006-2016. Over the same period, the price of imported rice on the Bamako market is relatively higher than that of the Kayes market. An increase in prices on the international market leads to higher prices on local markets (see Figure 1). Over the entire period, domestic prices for rice (imported and local) are well above the international price level except at the beginning of 2008 when the international price rose sharply. This price rising coincides with the 2006-2008 food crisis. From 2006 to 2016, the average price of imported rice is 313 CFA francs in Bamako and 297 CFA francs in Kayes, respectively. The average price for local rice is 328 CFA francs in Bamako and 387 CFA francs in Kayes. These average prices are almost double the average price on the international market (Table 1).

For imported rice prices, the coefficient of variation[4] is 0.30 for the international market, 0.11 for the Bamako market, and 0.09 for the Kayes market. The coefficient for local rice is 0.12 and 0.13 respectively for the Bamako and Kayes markets. The coefficients of variation show that domestic prices are more stable than international prices. This would be explained by the transaction costs between the international market and domestic markets.

The correlation coefficients are 0.28 for the international market and the Bamako market and 0.28 for the international market and the Kayes market respectively. For local rice, the coefficients are 0.18 for the international market and the Bamako market and 0.01 for the international market and the Kayes market. These results show that there is a positive correlation between the international market and domestic markets. Following the results of the descriptive analysis, we assume that there is an asymmetry in the transmission of international price shocks at national market prices.

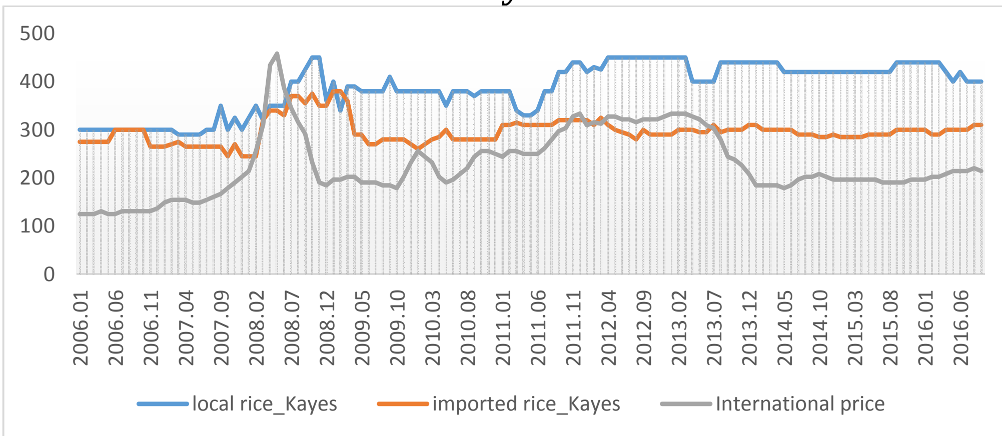
Figure 1: Evolution of local and imported rice prices in Mali

Bamako



[4] The coefficient of variation (CV) is obtained by comparing the standard deviation and the average of the price series. $CV = \frac{\sigma}{\bar{X}}$

Kayes



The world price is the export price of Thai rice (100% break A1)
Prices are expressed in CFA Francs/kg

3.2. Stationarity Tests

As price series in most agricultural market integration studies are generally non-stationary; it is therefore important to check this property by unit root tests. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are applied prior to any estimation in order to avoid making spurious regressions. The results of these different tests are presented in Table 2 below.

Table 2: Results of unit root tests on monthly data, Jan.2006- Sept.2016

		Bamako			Kayes			World Price		
			ADF	Prob		ADF	Prob		ADF	Prob
RI	At the level of	[1]	-0.25	0.60	[1]	-0.45	0.52	[1]	-0.74	0.39
	First Difference	[3]	-14.02	0.00	[3]	-11.13	0.00	[3]	-6.06	0.00
RL	At the level of	[1]	0.02	0.69	[1]	-0.00	0.68	[1]	-0.74	0.39
	First Difference	[3]	-14.84	0.00	[3]	-16.37	0.00	[3]	-6.06	0.00

Note: IR: Rice imported; RL: Local Rice; ADF: Dickey-Fuller Augmented; [1]: Model without constant or deterministic trend, critical value = - 1.95; [2]: Model with constant without deterministic trend, critical value = -2.89; [3]: Model with constant and deterministic trend, critical value = -3.45

The hypothesis that price series are non-stationary is tested using the Augmented Dickey Fuller test (ADF). The results of this test show that none of the price series is stationary at level, but they are all stationary in first difference. Therefore, these price series are I (1) integrated. Then we can apply Johansen's cointegration tests.

3.3. Standard integration tests

Johansen Cointegration Test

The Johansen cointegration test generally indicates the existence of a cointegration relationship between all market pairs at the 10% level (Table 3). It indicates that there is a long-term relationship between domestic prices and the world rice price.

Table 3: Johansen Cointegration Test Results

Markets	Types of rice	Hypothesis	Trace stat.	Critical value 5%	Maximum Eigen value	Critical value 5%
Bamako	Imported Rice	None	17.64***	15.49	12.04	14.26
		At most 1	5.60***	3.84	5.60***	3.84
	Local Rice	None	24.82***	15.49	16.88***	14.26
		At most 1	7.94***	3.84	7.94***	3.84
Kayes	Imported Rice	None	13.51*	15.49	8.67	14.26
		At most 1	4.84***	3.84	4.84***	3.84
	Local Rice	None	22.98***	15.49	15.43***	14.26
		At most 1	7.55***	3.84	7.55***	3.84

** indicates significance at the 10% threshold, ** significance at the 5% threshold and *** significance at the 1% threshold*

The Johansen test confirms the existence of a linear cointegration relationship between the prices of imported rice and the international rice price. For imported rice, the long-term relationship (Equation 1) provides a transmission elasticity of 0.14 for the Bamako market and 0.04 for the Kayes market. For local rice, a transmission elasticity of 0.12 is obtained for the Bamako market and 0.10 for the Kayes market (Table 4). The cointegration test of [22] is then applied to the residue of the long term relationship (Table 4). The number of lags in the equation is determined by the Akaike information criterion. The test results reflect the rejection of the null hypothesis of non-cointegration for the two markets in Mali. This means that domestic prices are integrated with the international price.

Table 4: Long-term relationship between international price and market price.

	Bamako		Kayes	
	Imported Rice	Local Rice	Imported Rice	Local Rice
Constant	1.02*** (0.02)	1.07*** (0.02)	1.04*** (0.03)	1.25*** (0.02)
World Price	0.14*** (0.02)	0.12*** (0.03)	0.04 (0.03)	0.10*** (0.03)
Obs	129	129	129	129

Note: The estimator is the least ordinary squares. The corrected standard deviations of heteroscedasticity are presented under the coefficients. ***, **, * (significance at 1%, 5%, 10%).

Generally speaking, the analysis of the behavior of rice markets (international and domestic markets) shows that markets are integrated with a long term response. The price adjustment is slow in Mali. This low adjustment rate can be explained by temporary VAT exemptions policies or customs duties on imports of rice implemented by the government to ensure food security. The Malian government exempted 40,000 tons of rice from VAT in 2002, 201,194 tons in 2005, 5,504 tons in 2007 and 105,789 tons in 2008 [20].

Table 5 presents the short-term dynamics estimate results of the standard error-corrected model for 2006-2016. Adjustment speeds are all significantly negative for all markets, justifying the existence of a short term dynamic between rice prices. Short term transmission elasticities appear to be relatively low.

Table 5: Standard Error Correction Model

	Bamako		Kayes	
	Imported Rice	Local Rice	Imported Rice	Local Rice
Adjustment	-0.32***	-0.39***	-0.09***	-0.28***

speed	(0.06)	(0.07)	(0.04)	(0.06)
Δ World Price	0.05 (0.07)	0.02 (0.09)	0.07 (0.06)	-0.02 (0.07)
Obs	128	128	128	128

Note: The estimator is the least ordinary squares. The corrected standard deviations of heteroscedasticity are presented under the coefficients. ***, **, * (significance at 1%, 5%, and 10%).

We also conduct the Granger causality test to determine the direction of trade flows (see Annex).

Granger Causality Test

It is crucial in studies like the one of market integration to determine the meaning of trade flows, since it is expected that producing regions will affect prices of consuming regions. Granger's causality tests have the merit of allowing us to determine the direction of the relationship. Indeed, these tests indicate the existence of a statistically significant relationship between lagged prices and prices at the time t. The aim is to test the nullity restrictions of system coefficients using a standard F-test for each equation. The sense of causation should therefore indicate the direction of relationship between producing and consuming areas. The results of the Granger tests for the two Malian markets are summarized in the Annex. The results of the Granger test reveal that the international rice prices cause, in the Granger sense, domestic prices in the two Malian markets. Trade flows are one way. This means that producing regions affect prices of consuming regions. These results confirm the central role played by the international market in the formation of rice prices in Mali.

3.4. Asymmetric integration tests

The results of the asymmetric cointegration test for a threshold of zero (Table 6) show that the coefficients ρ_1 and ρ_2 are significantly different from zero (based on *t*-max and F-test). The F-*test* values are 8.54 for Bamako – International and 6.48 for Kayes – International, respectively. These values appear to be higher than their different critical values at the 5% threshold depending on the number of lags. This result rejects the null hypothesis of non-cointegration which postulates that the coefficients ρ_1 and ρ_2 are jointly zero ($\rho_2 = \rho_1 = 0$). This means that there is an asymmetric co-integration between domestic and international prices. We then test the hypothesis of symmetrical adjustment. This hypothesis assuming the equality of coefficients ρ_2 and ρ_1 is tested from the Fisher standard test or Wald test. The test results provide values of 2.90 for Bamako – International and 3.10 for Kayes – International, respectively. The assumption of symmetric price adjustment is therefore rejected at the zero threshold for the Kayes local rice market and imported rice from Bamako.

These results mean that the shocks causing the positive deviations are more persistent than those causing the negative deviations in the two (02) Malian markets. In other words, the prices of local rice in Kayes and imported rice in Bamako respond more quickly to shocks resulting in global price increases than those resulting in lower prices on the international market.

Table 6: TAR Model Estimate with a Zero Threshold

	Bamako		Kayes	
	Imported Rice	Local Rice	Imported Rice	Local Rice
ρ_1	-0.22*** (0.09)	-0.17*** (0.10)	-0.08*** (0.05)	-0.24*** (0.10)
ρ_2	-0.32***	-0.28***	-0.13***	-0.20**

	(0.12)	(0.12)	(0.07)	(0.08)
Obs	126	126	125	123
t-max	-2.54*** [-2.11]	-2.39*** [-2.11]	-2.60*** [-2.21]	-2.36*** [-2.16]
F-test ($\rho_1 = \rho_2 = 0$)	8.54*** [6.05]	4.98 [6.05]	5.70 [5.96]	6.48*** [5.69]
Wald ($\rho_1 = \rho_2$)	2.90*** [2.86]	1.60 [2.77]	2.34 [2.74]	3.10*** [2.96]

Note: Parentheses numbers represent standard deviations. Numbers in brackets are critical values associated with statistics. *F* is the statistics of the joint test proposed by [26]. The Wald test is the ρ coefficient equality test. The number of TAR delays is determined by the Akaike information criterion.

Analysis of the short term dynamics from the asymmetric ECM shows that local rice prices in Kayes and imported rice price in Bamako respond significantly to positive and negative deviations from equilibrium. Indeed, for the market of imported rice in Bamako, the estimated values of $\rho_{1.1}$ and $\rho_{1.2}$ indicate that the adjustment of the domestic price allows to eliminate 8% of a negative deviation per unit from the threshold and 1% of a positive deviation. As regards the local rice market in Kayes, the results show that the adjustment of the domestic price makes it possible to eliminate 34% of a negative deviation from the threshold and about 23% of a positive deviation.

Table 7: Asymmetric Error Correction Model for a zero threshold

	Bamako		Kayes	
	Imported Rice	Local Rice	Imported Rice	Local Rice
$\boldsymbol{\rho_{1.1}}$	-0.01*** (0.04)	-0.18** (0.10)	-0.01** (0.07)	-0.23*** (0.13)
$\boldsymbol{\rho_{1.2}}$	-0.08**- (0.04)	0.50** (0.17)	-0.27** (0.11)	-0.34*** (0,11)
Obs	127	127	127	127
Wald ($\rho_{1.1} = \rho_{1.2}$)	19.8*** [3.08]	2.43 [2.74]	2.57 [2.64]	3.72*** [3.19]

Note: Numbers in brackets represent standard deviations. Numbers in brackets are critical values associated with statistics. The null hypothesis of the Wald test is H0: ρ1.1 = ρ1.2. The Ljung-Box test confirms the absence of autocorrelation of residues. ***, **, *(significance at 1%, 5%, 10%).

The Chan technique used to estimate thresholds yields respectively values of τ = -0.05 for Bamako – International; τ = 0.06 for Kayes – International (Table 8). The results of Table 8 show that coefficients ρ_1 and ρ_2 are significantly different from zero and are jointly different from zero (based on *t*-max and F-test). This means that there is an asymmetric compartmentalization between the prices of rice on national markets and the international price. The symmetric price adjustment hypothesis is also rejected for the markets of local rice in Kayes and imported rice to Bamako at endogenous thresholds.

Table 8: TAR model estimate with endogenous threshold determination

	Bamako		Kayes	
	Imported Rice	Local Rice	Imported Rice	Local Rice
Threshold	-0.064	-0.052	-0.092	0.057
$\boldsymbol{\rho_1}$	-0.18*** (0.08)	-0.20*** (0.10)	-0.07*** (0.04)	-0.12*** (0.11)
$\boldsymbol{\rho_2}$	-0.53*** (0.14)	-0.23*** (0.12)	-0.25*** (0.10)	-0.28*** (0.08)

Obs	126	126	125	123
t-max	-2.30 [-1.92]	-1.86** [-1.83]	-2.50 [-1.91]	-2.25 [-1.95]
F **($\rho_1 = \rho_2 = 0$)**	5.42 [6.95]	9.05*** [6.62]	5.21 [7.39]	7.14*** [6.95]
Wald **($\rho_1 = \rho_2$)**	4.77 [6.65]	7.30*** [6.83]	6.25 [7.20]	7.33*** [6.41]

Note: Parentheses numbers represent standard deviations. Numbers in brackets are critical values associated with statistics. *F* is the statistics of the joint test proposed by [26]. The Wald test is the ρ coefficient equality test. The number of TAR delays is determined by the Akaike information criterion.

Table 9: Asymmetric Error Correction Model with endogenous threshold determination

	Bamako		Kayes	
	Imported Rice	Local Rice	Imported Rice	Local Rice
$\rho_{1.1}$	-0.01*** (0.08)	-0.19** (0.04)	-0.06** (0.04)	-0.17*** (0.11)
$\rho_{1.2}$	-0.08** (0.04)	-0.61** (0.14)	-0.28** (0.09)	-0.25*** (0.07)
Obs	127	127	127	127
Wald **($\rho_{1.1} = \rho_{1.2}$)**	19.7*** [3.08]	2.33 [2.74]	1.70 [2.64]	3.48*** [3.19]

Note: Numbers in brackets represent standard deviations. Numbers in brackets are critical values associated with statistics. The null hypothesis of the Wald test is H0: $\rho 1.1 = \rho 1.2$. The Ljung-Box test confirms the absence of autocorrelation of residues. ***, **, *(significance at 1%, 5%, 10%).

4. CONCLUSION

The 2007-08 food crisis and the low production capacity of local rice exposed Mali to food imports including rice. The aim of this paper is to study the transmission of international price shocks into prices in the markets of Bamako and Kayes in highlighting factors likely to influence the degree of transmission. The main hypothesis of this study is based on the existence of asymmetry in prices transmission. We tested this hypothesis using monthly rice price data for the period from January 2006 to September 2016. Following tests based on the threshold autoregressive model (TAR), we conclude that the markets for local rice in Kayes and imported rice in Bamako react asymmetrically to price changes from the international market. Indeed, commercial intermediaries form an oligopolistic system which allows them to very quickly pass on price increases from international market to domestic prices at cost of consumers. This result confirms the influence of commercial intermediaries, public intervention and transaction costs on the transmission of prices, thus limiting the degree of integration of domestic markets into the international market. Better regulation of rice markets and more road infrastructure would limit the power of commercial intermediaries and contribute to a better functioning of market structures.

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ANNEX

Appendix 1: Granger Causation Test – Bamako Imported Rice Market

Null hypothesis	Test F	Probability
World price does not cause Granger Domestic price	3,59	0,03
Domestic Price Does Not Cause Granger World Price	0,40	0,67

Appendix 2: Granger Causation Test – Bamako Local Rice Market

Null hypothesis	Test F	Probability
World price does not cause Granger Domestic price	3,08	0,04
Domestic Price Does Not Cause Granger World Price	1,76	0,18

Appendix 3: Granger Causation Test – Kayes Imported Rice Market

Null hypothesis	Test F	Probability
World price does not cause Granger Domestic price	1,32	0,27
Domestic Price Does Not Cause Granger World Price	3,66	0,03

Appendix 4: Granger Causation Test – Kayes Local Rice Market

Null hypothesis	Test F	Probability
World price does not cause Granger Domestic price	4,31	0,01
Domestic Price Does Not Cause Granger World Price	3,88	0,02