Food Distribution Research Society

Journal of Food Distribution Research
Volume 51, Issue 1, pp. 7–16

Research Report: Market Integration in the Staple Food Derivatives Markets in Uganda

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Abstract

This paper examines the integration of staple food derivatives markets in Uganda. Monthly retail prices for white maize and cassava flour are collected from the Kampala central market and four geographically separated regional markets. Findings confirm significant long-run market integration among three of the eight market pairs and the presence of symmetric adjustment processes for all market pairs. Unidirectional and bidirectional Granger causality running from the central market of Kampala to the regional markets was confirmed, implying that while Kampala serves as the exogenous market, in some instances it is also influenced by regional market prices.

Keywords: cassava flour, Granger causality test, Kampala, staple food derivatives markets, TAR and M-TAR threshold autoregressive models, white maize flour

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Introduction

As documented in previous literature, food scarcity persists when food markets are not integrated because deficient markets fail to send the right signals to the surplus markets (Ghosh, 2003; Mukhtar and Javed, 2007; Katengeza, Kiiza, and Okello, 2013). This study, therefore, extends the literature by analyzing the level of market integration and determining the causal relationships among geographically separated staple food markets in Uganda. Although price integration in the staple food markets has been widely studied (Maleko, 2013; Minot, 2014; Yovo, 2017), very few studies exist for staple food derivatives markets in Uganda. The analysis focuses on two staple food derivatives markets—white maize and cassava flour. White maize flour is an important staple food derivative for the urban poor and those associated with institutional settings—hospitals, prisons, schools, and internally displaced person (IDP) refugee camps in northern Uganda (Benson, Mugarura, and Wanda, 2008; Famine Early Earning System, 2017). Similarly, cassava flour is essential for those in Eastern Uganda, where it is often mixed in various proportions with millet flour to produce a more nutritious and tasty composite meal to meet household dietary needs (Kleih et al., 2012).

Kampala, which accounts for about 50% of the formal staple food trade in Uganda, serves as the reference market. The selected regional markets are Mbarara in the west, Iganga in the east, and Gulu and Lira, which are critical markets serving the structurally deficit Karamoja subregion (Famine Early Warning System, 2017), in the north. Threshold autoregressive approaches (TAR and M-TAR) and Granger causality tests are employed to examine integration between the selected regional markets and the central market.

Methodology

Cointegration Testing

There are several time-series techniques for testing the different components of price transmission and thus ultimately assessing the extent of market integration. This study uses the threshold autoregressive approach, extended by Balke and Fomby (1997) to a cointegration framework and by Enders and Siklos (2001) to allow asymmetric adjustments when testing for a long-run relationship between two time series. Consider, for instance, the long-run equilibrium relationship between price series P^C_t (price at the central market) and P^L_t (price at the local, regional markets), such that

(1) $$P_t^C = \alpha_0 + \alpha_1 P_t^L + e_t,$$

where P^C_t and P^L_t are nonstationary series, e_t is a random error term with constant variance, α_0 is an arbitrary constant that accounts for price differential (e.g., transportation costs) and α_1 is the estimated parameter of the cointegration regression. Then, according to Engle and Granger (1987), the long-run market integration within this framework involves testing whether the marketing margin (e_t) is stationary by estimating the following relationship:

(2) $$\Delta e_t = \rho e_{t-1} + \varepsilon_t,$$

where the lags of the dependent variable can be included by relying on information criterions (such as the Akaike information criterion) to ensure that the error term (ε_t) is a white-noise process. Accordingly, stationarity of the residuals (i.e., $-2 < \rho < 0$) with mean 0 indicates rejection of the null hypothesis of no cointegration ($\rho = 0$), where the *t*-statistic is compared to the Dickey–Fuller critical values for unit root test.

In the presence of asymmetric adjustment, however, the Engle and Granger (1987) cointegration approach is incorrectly specified since it implicitly assumes linear and symmetric adjustment mechanism (Enders and Siklos, 2001). Enders and Siklos have extended the famous two-step symmetric Engle–Granger procedure, providing an approach that allows asymmetric adjustments toward long-run equilibrium to occur when testing for a long-run relationship. Their threshold autoregressive (TAR) and momentum-threshold autoregressive (M-TAR) testing procedures account for a nonzero threshold to reflect positive transaction costs. The TAR-consistent model takes the form

(3) $$\Delta e_t = I_t \rho_1 e_{t-1} + (1 - I_t)\rho_2 e_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta e_{t-i} + \varepsilon_t,$$

where I_t is the Heaviside Indicator function, such that

(4) $$I_t = \begin{cases} 1 & \text{if } e_{t-1} \geq \tau \\ 0 & \text{if } e_{t-1} < \tau, \end{cases}$$

and τ is the threshold value. As an alternative adjustment process, the M-TAR-consistent model is specified as

(5) $$\Delta e_t = M_t \rho_1 e_{t-1} + (1 - M_t)\rho_2 e_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta e_{t-i} + \varepsilon_t,$$

where I_t is the Heaviside Indicator function, such that

(6) $$M_t = \begin{cases} 1 & \text{if } \Delta \hat{e}_{t-1} \geq \tau \\ 0 & \text{if } \Delta \hat{e}_{t-1} < \tau. \end{cases}$$

According to Enders and Granger (1998), the M-TAR-consistent model is especially valuable when the series exhibits more "momentum" in one direction than in the other. It allows the autoregressive decay to depend on Δe_{t-1}. The adjustment is then modeled by $\rho_1 e_{t-1}$ if Δe_{t-1} is above the threshold and by $\rho_2 e_{t-1}$ if Δe_{t-1} is below the threshold. If $|\rho_1| > |\rho_2|$, the M-TAR model exhibits little decay for negative Δe_{t-1} but substantial decay for positive Δe_{t-1}. Estimating the threshold models requires some method for estimating the threshold parameter, τ. This study employs Chan's (1993) method, and the lag selection is based on the AIC.

To test for threshold cointegration, Enders and Siklos (2001) proposed two types of tests: the Φ and *t*-Max statistics. The Φ statistic (using an *F*-statistic) involves procedure testing for the null hypothesis of no cointegration ($H_0 : \rho_1 = \rho_2 = 0$); the *t*-Max statistic (employing a *t*-statistic) requires the test for the null hypothesis with the largest $\rho_i = 0$ between ρ_1 and ρ_2. The threshold parameter τ, which is restricted to the ranges of the remaining 70% of $\hat{e}_t$ or $\Delta\hat{e}_t$ when the largest and smallest 15% values are discarded, is selected as an unknown value to minimize the sum of the squared residuals obtained from equations (3) and (5). In the presence of asymmetric cointegration, the null hypothesis $(H_0 : \rho_1 = \rho_2)$ is tested using the standard *F*-statistics. Accordingly, the evidence in support of asymmetric adjustment of the error correction term is indicated when both $H_0 : \rho_1 = \rho_2 = 0$ and $H_0 : \rho_1 = \rho_2$ are rejected.

Testing for Causality

The focus here is on the question of whether price at the central market (P^C) causes price at the regional market (P^L) and vice versa (Engle and Granger, 1987). This is accomplished by examining how much of the current price at the regional markets can be explained by past values and then whether adding lagged values of P^C can improve the explanation. The Granger model can be represented as

(7) $$\Delta P_{it} = \sum_{i=1}^{m} a_i \Delta P_{i(t-1)} + \sum_{j=1}^{n} a_j \Delta P_{j(t-1)} + \ell_t,$$

where *m* and *n* are the number of lags determined by a suitable information criterion. Rejection of the null hypothesis would imply that prices in market *j* Granger-cause prices in market *i*. If prices in market *i* also Granger-cause prices in market *j*, this implies bidirectional causality. If the Granger causality runs one way, implying unidirectional Granger causality, the market that Granger-causes the other is tagged the exogenous market.

Data

The data consist of monthly retail prices (in Ugandan shillings (UGX)/kg) of white maize flour and cassava flour at the central market of Kampala (Owino) and four geographically separated markets: Mbarara, Gulu, Iganga, and Lira. Data from January 2010 through July 2018 are sourced from the World Food Programme (2019).[1] Figures 1 and 2 plot these data for cassava and white

[1] Missing data were a problem, particularly price data in Iganga and Mbarara, where six to eight intermediate monthly data points were missing. These were approximated using the square root of the month immediately before and immediately after the missing data point. When two consecutive data points were missing, the average of the last three immediate data points before was used for the first missing data point and the square root process was followed for the second missing data point.

maize flour, respectively. The series exhibits a relatively uniform pattern, with sharp changes occuring in the short term (within 2–3 months). The high degree of inter- and intra-annual variation observed, particularly in Gulu, is more likely caused by political insecurity, which limits the supply of commodities from both within the district and nearby areas, and World Food Programme distributions of maize in the region (Famine Early Warning System, 2017).

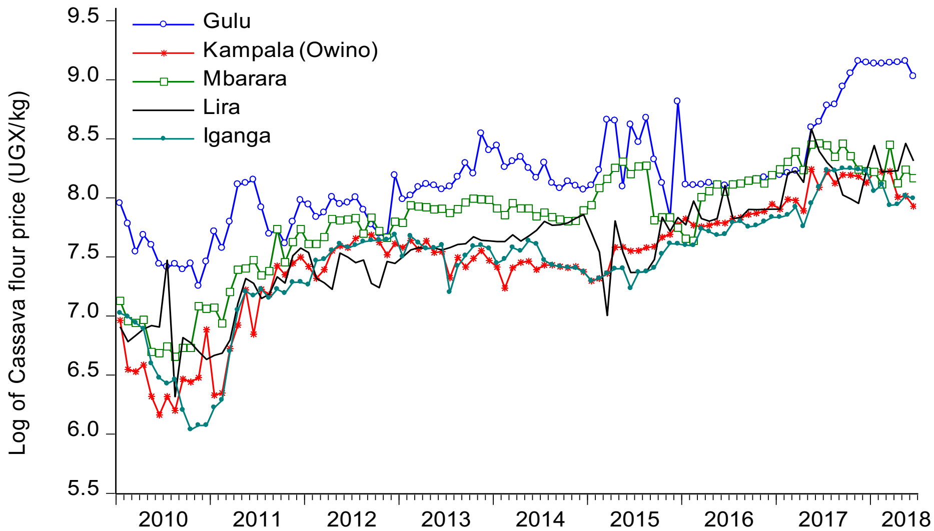

Figure 1. Cassava Flour Price Series

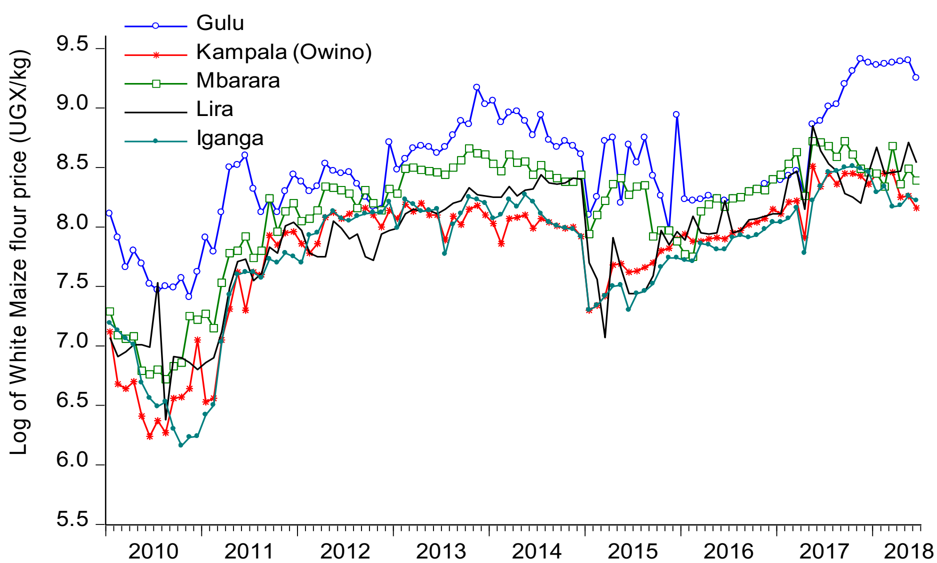

Figure 2. White Maize Flour Price Series

Empirical Results

Before performing cointegration analysis, all data series were adjusted for inflation using a monthly composite consumer price index (CPI) for food,[2] which was sourced from the Uganda Bureau of Statistics (Uganda Bureau of Statistics, 2011–2018) and transformed logarithmically. The hypothesis of nonstationary was tested using the augmented Dickey–Fuller (ADF) and the Phillips–Perron (PP) tests (Table 1). The optimal number of lags was automatically determined based on the Schwarz information criterion (SIC) using EViews 9 software package. All tests confirmed a single unit root, implying that prices in the derivatives markets are nonstationary. In the second step, Enders and Siklos (2001) threshold cointegration approaches (TAR and M-TAR models) were conducted. Table 2 reports the results.

Table 1. ADF and PP Unit Root Tests

	Augmented Dickey–Fuller (ADF) Test				Phillips–Perron (PP) Test			
	Levels	Lag	Diff.	Lag	Levels	Lag	Diff.	Lag
Maize flour								
Gulu	−1.461	1	−13.746**	0	−1.880	6	−14.290**	4
Iganga	−1.414	0	−9.357**	0	−1.606	4	−9.405**	3
Lira	−2.512	0	−14.480**	0	−2.200	1	−15.470**	8
Mbarara	−1.965	1	−13.173**	0	−1.827	1	−13.216**	1
Kampala	−1.747	0	−12.710**	0	−1.617	1	−12.990**	4
Cassava flour								
Gulu	−1.079	1	−14.173**	0	−1.505	5	−14.173**	0
Iganga	−1.034	0	−8.790**	0	−1.327	5	−8.918**	4
Lira	−1.530	1	−15.624**	1	−1.918	1	−25.395**	16
Mbarara	−1.699	1	−12.901**	0	−1.543	2	−12.958**	2
Kampala	−1.477	1	−14.273**	0	−1.272	1	−14.687**	5

Note: Double asterisks (**) denote rejection of the null hypothesis at the 1% level. Lag lengths in the ADF test are based on the SIC and on the Newey–West bandwidth in the PP test.

The TAR and M-TAR findings show that the F-joint statistics ($\rho_1 = \rho_2 = 0$) for the cassava flour model are greater than the critical values calculated using a Monte Carlo experiment approach for the Kampala–Iganga market pair, implying the existence of a long-run relationship between the Kampala central market and the Iganga regional market. However, the F-equal statistics ($\rho_1 = \rho_2$) are lower than the simulated critical values at the 5% significance level, suggesting that the null hypothesis of symmetric adjustments cannot be rejected across all cassava flour market pairs. Together, the results help to conclude that cassava flour prices are only cointegrated between the Kampala central market and the Iganga regional market, depicting symmetric adjustment processes.

[2] The CPI series (2011–2015, 2016–2017, and 2018) obtained were generated using different base years. For uniformity, the old series were rebased using the base from the latest series, and a consistent CPI was generated with a uniform base year.

Table 2. Enders and Siklos Cointegration among Cassava and White Maize Flour Price Series

	Cassava Flour Market				**White Maize Flour Market**			
	TAR		**M-TAR**		**TAR**		**M-TAR**	
	Coeff.	**SE/CV**	**Coeff.**	**SE/CV**	**Coeff.**	**SE/CV**	**Coeff.**	**SE/CV**
Kampala–Gulu market pair								
ρ_1	−0.057	0.081	−0.070	0.073	−0.064	0.082	−0.092	0.075
ρ_2	−0.212*	0.085	−0.267*	0.107	−0.235*	0.092	−0.251*	0.114
τ	−0.217		−0.064		−0.292		−0.069	
$\rho_1 = \rho_2$	1.864	[6.548]	2.248	[8.015]	2.080	[6.475]	1.393	[8.152]
T-max value	−0.707	[−1.902]	−0.961	[−1.847]	−0.787	[−1.893]	−1.229	[−1.813]
$\rho_1 = \rho_2 = 0$	3.284	[7.037]	3.485	[8.081]	3.471	[6.972]	3.111	[8.036]
Lags	2		2		2		2	
Kampala–Iganga market pair								
ρ_1	−0.523*	0.142	−0.855*	0.162	−0.652*	0.163	−0.784*	0.158
ρ_2	−0.715*	0.148	−0.506*	0.124	−0.440*	0.121	−0.390*	0.117
τ	−0.063		−0.090		0.141		0.088	
$\rho_1 = \rho_2$	1.191	[6.694]	4.389	[8.249]	1.425	[6.526]	5.534	[8.005]
T-max value	−3.680*	[−1.958]	−4.078*	[−1.857]	−3.633*	[−1.913]	−3.343*	[−1.857]
$\rho_1 = \rho_2 = 0$	14.776*	[6.933]	16.878*	[7.996]	11.733*	[6.860]	14.277*	[7.922]
Lags	5		5		4		4	
Kampala–Lira market pair								
ρ_1	−0.371*	0.139	−0.432*	0.154	−0.355*	0.122	−0.189*	0.097
ρ_2	−0.211	0.177	−0.224	0.142	−0.272*	0.117	−0.642*	0.150
τ	−0.193		0.051		−0.204		−0.226	
$\rho_1 = \rho_2$	0.634	[6.557]	1.424	[8.040]	0.274	[6.328]	7.217	[8.129]
T-max value	−1.188	[−2.055]	−1.578	[−1.929]	−2.336*	[−1.889]	−1.948*	[−1.905]
$\rho_1 = \rho_2 = 0$	3.768	[6.589]	4.197	[7.711]	7.274*	[7.082]	10.184*	[8.237]
Lags	9		9		1		1	
Kampala–Mbarara market pair								
ρ_1	−0.325*	0.162	−0.318*	0.123	−0.125	0.118	−0.072	0.110
ρ_2	−0.229*	0.112	−0.144	0.139	−0.237*	0.093	−0.287*	0.096
τ	0.108		−0.038		0.158		0.020	
$\rho_1 = \rho_2$	0.409	[6.582]	1.404	[8.080]	0.631	[6.701]	2.458	[8.043]
T-max value	−2.010	[−2.049]	−1.036	[−1.903]	−1.060	[−1.895]	−0.649	[−1.835]
$\rho_1 = \rho_2 = 0$	2.828	[6.629]	3.358	[7.652]	3.515	[6.908]	4.490	[8.077]
Lags	9		9		2		2	

Note: A single asterisk (*) denotes significance at the 5% level. Numbers in brackets are simulated critical values from the Monte Carlo experiment approach. Optimal lag order is based on the AIC.

In the white maize flour models, the *F*-joint statistics are higher than the simulated Monte Carlo critical values only for the Kampala–Iganga and Kampala–Lira market pairs. It implies that for the maize flour markets, the null hypothesis of no cointegration is rejected at the 5% level only for Kampala-Inganga and Kampala-Lira market pairs. Similar to the cassava model, the estimated *F*-equal statistics for all maize flour market pairs are lower than the simulated critical values at the 5% significance level, which is an indication of the symmetric adjustment process. The results for the maize flour market pairs help to conclude that although the adjustment process is symmetric for all white maize flour market pairs, the long-run relationship exists only between the central market of Kampala and Iganga and Lira regional markets.

Table 3. Granger Causality Test for Staple Food Derivatives Markets in Uganda

Null Hypothesis	No. of Obs.	*F*-Statistic	Prob.	Results
Maize flour market pairs				
Gulu does not Granger-cause Kampala	100	0.045	0.956	None
Kampala does not Granger-cause Gulu		2.355	0.100	
Iganga does not Granger-cause Kampala	98	2.195*	0.076	Bidirectional
Kampala does not Granger-cause Iganga		6.027**	0.000	
Lira does not Granger-cause Kampala	101	0.276	0.601	Unidirectional
Kampala does not Granger-cause Lira		18.837**	0.000	
Mbarara does not Granger-cause Kampala	100	0.540	0.584	None
Kampala does not Granger-cause Mbarara		1.278	0.283	
Cassava flour market pairs				
Gulu does not Granger-cause Kampala	100	0.001	0.999	Unidirectional
Kampala does not Granger-cause Gulu		2.592*	0.080	
Iganga does not Granger-cause Kampala	97	2.915**	0.018	Bidirectional
Kampala does not Granger-cause Iganga		8.308**	0.000	
Lira does not Granger-cause Kampala	93	2.434**	0.018	Bidirectional
Kampala does not Granger-cause Lira		1.808*	0.081	
Mbarara does not Granger-cause Kampala	93	1.103	0.372	None
Kampala does not Granger-cause Mbarara		1.547	0.148	

Note: Single and double asterisks (*, **) denote significance at the 10% and 5% levels, respectively.

Table 3 reports the Granger causality results, revealing one unidirectional (Kampala–Lira) and one bidirectional (Kampala–Iganga) causality in the white maize flour markets and one unidirectional (Kampala–Gulu) and two bidirectional (Kampala–Iganga and Kampala–Lira) causalities in the cassava flour markets. The unidirectional causality results imply that the null hypothesis that price at the Kampala central market does not Granger-cause prices at the Lira and Gulu regional markets can be rejected but not vice versa. Thus, information on the price at the Kampala market improves the predictions on the prices at the Lira and Gulu markets. Likewise, the bidirectional causality results imply that both the null hypothesis that price at the Kampala market does not Granger-cause prices at the Lira and Iganga markets, and the null hypothesis that prices at the Lira and Iganga markets do not Granger-cause prices at the Kampala market can be rejected. Thus, information on the price at the Kampala market improves the predictions on the prices at the Lira and Iganga markets and vice versa.

Conclusions

The long-run price-adjustment mechanism between the retail prices of white maize and cassava flour at the Kampala central market and four regional markets—Gulu, Lira, Mbarara, and Iganga—were tested using monthly data from January 2010 through July 2018. Unit root, TAR, M-TAR, and Granger causality tests were employed. The results lead to a few conclusions on the status of market integration in Uganda. First, long-run market integration was confirmed for three market pairs and the presence of symmetric adjustment processes was confirmed for all market pairs. Second, unidirectional and bidirectional Granger causality from the Kampala market to two regional markets was confirmed, implying that Kampala serves as the exogenous market for white maize prices in Lira and cassava prices in Gulu. Thus, price information from the Kampala market improves price predictions at the Lira (white maize) and Gulu (cassava) regional markets. On the other hand, price information from the Kampala market improves price predictions at the Iganga (for both derivatives) and Lira (for cassava) regional markets and vice versa.

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