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Spatial Integration of Milk Markets in Uganda

Ronald Kabbiri[1a,b], Manoj K. Dora[c], Mohammad J. Alam[d], Gabriel Elepu[e], and Xavier Gellynck[a]

[a] *Department of Agricultural Economics, Ghent University, Belgium*

[b] *Department of Applied Sciences, Mountains of the Moon University, Uganda*

[c] *Brunel Business School, Brunel University London, UK*

[d] *Department of Agribusiness & Marketing, Bangladesh Agricultural University, Bangladesh*

[e] *Department of Agribusiness & Natural Resource Economics, Makerere University, Uganda*

Ronald.Kabbiri@ugent.be

ABSTRACT
This paper examines whether milk prices within Kampala are cointegrated with those in other major towns of Uganda. The period of estimation is from July 2005 to March 2015. We use retail monthly prices for raw milk. We obtained the dataset from Uganda Bureau of Statistics. Using Engel Granger's two-step error correction approach, we examine the relationship that exists between prices for raw milk in Kampala and the regional markets. Our analysis provides evidence of a long-run cointegration relationship between Kampala and Gulu, Mbarara and Masaka milk markets. On the contrary, we failed to reject the null hypothesis of no cointegration between Kampala and Arua, Jinja and Mbale milk markets. Regarding the Granger causality tests, the results reveal that causality mainly originates from the milk supply towns. This implies that milk prices in Uganda are supply driven. The speed of adjustment of the model is 50%, i.e. half of the disequilibrium in the system is corrected in one month time period. These results have important implications for the dairy sector in Uganda. The paper discusses these implications.

Key words: *Error correction model, inter-market relationships, dairy value chain, milk price transmission, speed of adjustment*

1.0 Introduction

Market integration is an important determinant of responsiveness and behaviour of spatially integrated markets. The extent to which two or more markets are integrated often determines their level of efficiency. Normally, market integration is taken as a measure of market efficiency (Baulch, 1997, Federico, 2012). As such, a lot of work has been done on market integration of food markets all over the world.

Some studies found weak or strong integration in food markets whereas others did not find any integration. Some studies rejected the integration hypothesis and concluded that the food markets they studied were integrated (Abdulai, 2000, Gonzalez-Rivera and Helfand, 2001, García-Enríquez et al., 2014). Other studies, on the other hand, failed to reject the integration hypothesis and concluded that the food markets they studied were not integrated (Gardner and Brooks, 1994, Zhou et al., 2000).

This paper examines whether milk prices within Kampala are cointegrated with those in other major towns of Uganda. Kampala is taken as a central market since it is the country's capital city. It is also the main market for

[1] Corresponding author: Ronald.Kabbiri@ugent.be

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most produce including milk because of high demand for the product in the city. A central market is very important in market integration analysis for a number of reasons (Ravallion, 1986). Generally, arbitrage, which is the driving force behind market integration, works in between all markets which are integrated. Nevertheless, if price is determined in a central market, and transmitted to regional markets, shocks in the latter do not influence prices in the former (Asche et al., 2012).

A lot of empirical work on food market integration has been on grains, probably because of their importance in food security (Aker et al., 2014, García-Enríquez et al., 2014, Gardner and Brooks, 1994, Ghoshray and Ghosh, 2011, Rashid, 2004, Zhou et al., 2000). There are also studies on milk market integration. Studies by Acosta et al. (2014), Amador et al. (2010), Bakucs and Fertö (2007), Jha et al. (2012), and Bakucs et al. (2010) looked at various aspects of market integration such as price transmission and price volatility in milk markets. Most of these studies apply methodologies which mainly assess long-run relationships. The aspect of short-run relationships is normally left out in most studies.

Our study complements and expands on earlier studies in several ways. The methodology we use, the Engle-Granger two-step modelling method, can model both the long-run and short-run equilibrium relationships. We supplement this methodology with the Granger causality tests, which measures the direction of causality of the milk price pairs.

Uganda, a country whose data we used for this study, is largely dependent on agriculture. In the early 1990s, the country made a commitment to pursue a market economy. Under this commitment, the government is not supposed to intervene in food markets. Its role is limited to facilitating and promoting the participation of the private sector. Obviously, it may be rather optimistic to expect that a thoroughly regulated economy should easily convert itself into a well-functioning market economy simply by non-government intervention. Rashid (2004) analysed the performance of maize markets in Uganda following agricultural liberalisation. His results show an overall improvement in spatial market integration in maize markets. Our article is a contribution to such analyses, which should form the foundation for the development of more advanced market regulation, i.e., regulation having the purpose of generating well-functioning, competitive markets.

In the next section, we present the methodology and data. Section three presents and discusses results and the conclusions and implications are in the last section of the article.

2.0 Methodology and data

2.1 Methodology

We applied the Engle-Granger two-step modelling approach (EG) for testing for cointegration. The EG, as originally suggested by Engle and Granger (1987), has received a great deal of attention. One of its benefits is that it can model the long-run equilibrium relationship by a straightforward regression involving levels of variables. In the first step of the model, we ignore all the dynamics and estimate the cointegrating regression by OLS.

$$P_t^i = \beta P_t^j + u_t \tag{1}$$

where P_t^i and P_t^j are prices of any milk market i and j, respectively; these prices are non-stationary and integrated of order one (i.e. $P_t^i \sim I(1)$ and $P_t^j \sim I(1)$. u_t is the error term. In order for P_t^i and P_t^j to be cointegrated, the necessary condition is that the estimated residuals from equation (1) should be stationary (i.e. $u_t \sim I(1)$. Since the variables in equation (1) are non-stationary, we should place little faith in the standard error estimates in the cointegrating regression. For this reason, little importance can be attributed to the standard statistical tests on R^2 or t-statistics of the estimated coefficients unless a correction procedure is employed to eliminate the bias. Different types of corrections are reported by Engle and Granger (1991), Park and Phillips (1988) and Phillips and Hansen (1990).

In the second step, we estimate a short-run model with an error-correction mechanism by OLS. According to the Granger Representation Theorem, if a number of variables, such as P_t^i and P_t^j, are cointegrated, then there will exist an error correction mechanism relating these variables and vice versa (Engle and Granger, 1987). Conditional on finding cointegration between P_t^i and P_t^j, the estimate of β from the first step long-run regression may then be imposed on the following short-run model with the remaining parameters being

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consistently estimated by OLS. That is to say, we retrieve the estimate of β from equation (1), and insert it in place of β in the error-correction term $(P_t^i - \beta P_t^j)$ in the following short-run equation:

$$\Delta P_t^i = \propto_1 \Delta P_t^j + \gamma(P_t^i - \beta P_t^j)_{t-1} + \varepsilon_t \qquad (2)$$

where Δ represents first-differences and ε_t is the error term. Alternatively, in practice, since $P_t^i - \beta P_t^j = \mu_t$, one can substitute the estimated residuals from equation (1) in place of the error-correction term, as the two will be identical. Note that the estimated coefficient γ in the short-run equation (2), also known as speed of adjustment, should have a negative sign and be statistically significant. For the variables in hand to be cointegrated, negative and statistically significant γ is a necessary condition. In practice, this is regarded as a convincing evidence and confirmation for the existence of cointegration found in the first step.

It is also important to note that, in the second step of the EG approach, there is no danger of estimating a spurious regression since stationarity of the variables is ensured. Combinations of the two steps then provides a model incorporating both the static long-run and the dynamic short-run components.

2.2 Data
The dataset for the analysis consists of monthly retail prices of milk for the period from July 2005 to March 2015. The data is from Uganda Bureau of Statistics (UBOS). Prices are reported monthly by trade agents located in major milk markets in Uganda, which include, Kampala, Jinja, Mbale, Masaka, Mbarara, Gulu and Arua. Kampala is the central market and the rest are regional markets. The complete dataset contains 117 observations per market.

Figure 1 shows the time path of the milk prices. We can observe that prices generally show trending behaviour. Generally, the prices seem to move together over time and display an upward drift. It is hard to tell whether the prices are characterised by deterministic or stochastic trends. Hence, it is appropriate to conduct unit root tests to ascertain the nature of the trends in the milk prices.

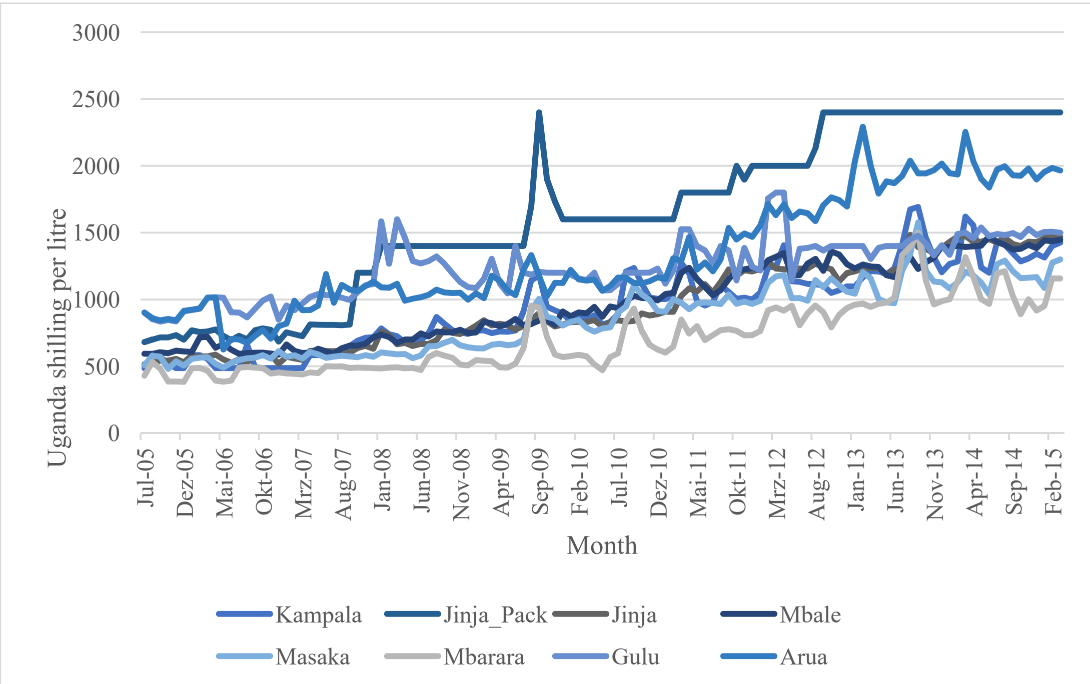

Figure 1. Milk price series for major towns in Uganda

3.0 Results
3.1 Time series properties of the dataset

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We tested all the price series for their order of integration prior to the examination of the relationships that may exist between them. The augmented Dickey-Fuller (ADF) test was applied to the data in levels and first differences. The summary of the unit root tests is presented in Table 1.

Whereas we could not reject the null hypothesis of a unit root for all the data in levels, we could reject it in first differences for all the data. From these unit root tests, we can conclude that all the price series are non-stationary and integrated of order one, that is, I(1). The lag length given in brackets in Table 1 is chosen according to the Schwarz information criterion (Asche et al., 2007).

Table 1. Augmented Dickey-Fuller (ADF) test results

Milk market centres	Level	First difference
Arua	-0.35 (3)	-9.54 (2)***
Gulu	-2.66 (1)	-14.78 (0)***
Jinja	-0.211 (1)	-13.37 (0)***
Kampala	-1.06 (3)	-9.47 (2)***
Mbale	-0.62 (0)	-8.89 (2)***
Mbarara	-0.90 (4)	-8.80 (3)***
Masaka	-0.25 (9)	-7.28 (8)***

Note: ***(P<0.01); the numbers in parentheses denote lag length chosen according to the Schwarz information criterion (Asche et al., 2007). The p-values are as per MacKinnon et al. (1998).

3.2 Estimation of long-run regression model

After establishing the order of integration of the prices, we then estimated equation (1), extracted error terms and tested for their stationarity. The regression results of equation (1) are shown in Table 2.

The results of the long-run regression model show that the prices in half of the Ugandan regional milk markets are cointegrated with the Kampala market (Table 2). Gulu, Mbarara and Masaka milk markets are in a long-run equilibrium relationship with Kampala. This means that price transmission is from these towns to Kampala. The three towns are close to Kampala and are connected by a very good road network, which enables quick flow of information. Traders in these towns are also in close contact with each other. Information exchange is very fast due to good communication infrastructure. The good infrastructure is an incentive for the traders to move milk between these markets.

Kampala, being a city centre, does not produce milk. It just receives from other parts of the country. The large quantity of milk that comes from the regional towns, especially Mbarara, also accounts for market integration. According to González-Rivera and Helfand (2001), a large volume of inter-regional trade can lead to a higher degree of integration because it contributes to reducing transactions costs. The dairy industry in Uganda has been liberalised since 1993. The private sector has a capacity of improving on the extent of price transmission in a liberalised economy. Studies conducted in Malawi, Ethiopia, Uganda and some countries in the European Union show that market liberalisation can improve on price transmission and market integration (Dercon, 1995, Rashid, 2004, Goletti and Babu, 1994).

Arua, Jinja and Mbale, on the other hand, are not in a long-run equilibrium relationship with Kampala. Being the furthest from Kampala, Arua can hardly be cointegrated with Kampala. Arua is about 480 km from Kampala. Besides, it also produces very little milk. Most probably this milk is consumed within the district. Jinja and Mbale are both in eastern Uganda, a region that does not produce much milk. The low quantity of milk together with other factors like distance and quality of roads increase the chance of the null hypothesis of no cointegration not to be rejected.

Table 2. Long-run cointegration relationship[2]

[2] After carrying out all the above tests, we subjected our model to tests of serial correlation, normality and heteroskedastity. This was to ensure that our model does not violate any of the OLS assumptions. For serial correlation, we used Breusch-Godfrey serial correlation LM Test. For normality, we used the Jarque-Bera test for normality. And for heteroskedastity, we used the Breusch-Pagan-Godfrey test. Results from all these tests show that our model was free from all the above regression errors.

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Dependent variable: Kampala

Milk market	Coefficient	t-Statistic	Probability
Intercept	-173.52	-4.02	0.0001
Arua	-0.06	-1.19	0.236
Gulu	0.24	4.79***	0.0000
Jinja	0.03	0.25	0.8036
Mbale	0.09	0.66	0.5078
Mbarara	0.56	6.27***	0.0000
Masaka	0.45	4.17***	0.0001

Note: ***(P<0.01)

3.3 Error correction model (ECM)

The existence of cointegration between the price pairs allows us to estimate an ECM. After estimating the long-run equilibrium relationship given by equation (1), we conducted the ADF test on the residuals in equation (1). We found that the residuals were stationary using Engle and Granger (1987) critical values, which led us to estimate a short-run model as shown in equation (2) and Table 3.

Table 3. Error correction model

Dependent variable: Kampala

Variable	Coefficient	t-Statistic	Probability
Intercept	-1.51	-0.27	0.787
Arua	0.04	0.80	0.4251
Gulu	0.14	2.90**	0.0045
Jinja	0.23	1.73*	0.0873
Mbale	0.26	1.10*	0.0481
Mbarara	0.56	7.29***	0.0000
Masaka	0.20	2.10**	0.0377
Speed of adjustment	-0.50	-6.15***	0.0000

Note: ***(P<0.01); ***(p<0.05); *(p<0.1)

From our short-run model, we conducted tests for Granger causality. Granger causality is tested by conducting joint hypothesis tests from the ECMs to find out whether lagged ΔP_t^i (say) can be used to forecast ΔP_t^j. For instance in equation (2), we tested the hypothesis $H_0\colon \lfloor \alpha_1 = \alpha_2 = \cdots = \alpha_p = 0 \rfloor$. If we reject the null hypothesis, it would mean that ΔP_t^jGranger causes ΔP_t^i, or alternatively, ΔP_t^jcan be used to forecast ΔP_t^i. Table 4 shows the Granger causality test results. In this analysis, we only found bidirectional causality to exist for three out of the six price pairs. For instance, Mbarara prices can be used to forecast Kampala prices, while Kampala prices in turn can be used to forecast Mbarara prices. Mbarara prices can also be used to forecast Masaka prices, just like Masaka prices can be used to forecast Mbarara prices. Kampala prices can also be used to forecast Masaka prices, and Masaka prices can be used to forecast Kampala prices. Some price pairs, however, do not show any significant causality. Price pairs like Gulu/Kampala, Gulu/Masaka, Gulu/Mbarara do not show any significant causality. On the other hand, some price pairs do not show any relationship, i.e. they do not show any market integration. This is because we carried out Granger causality tests for only the markets which were in a long-run relationship with Kampala.

Generally, these results show that causality mainly originates from the milk supply regions. In other words, milk prices in Uganda are largely supply driven.

Table 4. Causality among milk markets in Uganda

				To			
From	Arua	Gulu	Jinja	Kampala	Masaka	Mbale	Mbarara
Arua		-	-	-	-	-	-
Gulu	-		-	n.c.	n.c.	-	n.c.

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Jinja	-	-		-	-	-	-
Kampala	-	n.c.	-		**	-	***
Masaka	-	n.c.	-	***		-	**
Mbale	-	-	-	-	-		-
Mbarara	-	n.c.	-	***	**	-	

Note: -, markets not integrated; n.c., no significant causality; *, causality found at the significant levels, i.e. *** (P<0.01); ** (P<0.05); * (P<0.10).

3.4 Speed of adjustment

From Table 3, the speed of adjustment of our model is –0.50 (50%), and is also very significant (p<0.01). In practice, this is regarded as a convincing evidence and confirmation for the existence of cointegration found in the first step of EGM (Engle and Granger, 1987). This means that, in case of a shock that brings about disequilibrium in the system, half this disequilibrium is corrected in one month's time period.

4.0 Conclusions and implications

This article investigates the Ugandan milk markets from July 2005 to March 2015 using the Engel-Granger two-step modelling approach. We chose this method because many other tests of cointegration did not reveal any relationship in our markets. The milk markets we studied are Arua, Gulu, Jinja, Mbale, Mbarara, Masaka and Kampala. The analysis provides evidence of a long-run cointegration relationship between Kampala and Gulu, Mbarara and Masaka. On the contrary, there is no cointegration between Kampala and Arua, Jinja and Mbale. Regarding the Granger causality tests, the results reveal that causality mainly originates from the milk markets that supply Kampala, which is the central market. This implies that milk prices in Uganda are supply driven. The speed of adjustment of the model is 50%, which implies that, in case of a shock, half of the disequilibrium in the system is corrected in one month's time period.

These results have important implications for the dairy sector in Uganda. Since 1993, the dairy industry has been liberalised. The limited government intervention has contributed a lot to spatial integration of milk markets in Uganda. The only way the government is involved in this sector is through setting up quality standards through its agencies, like the Dairy Development Authority and Uganda National Bureau of Standards.

Our results also lend support to the argument that infrastructure is very important in market integration. The milk markets that we found to be in a long-run relationship with Kampala have very good physical, communication and market infrastructure. This implies that infrastructure development can be helpful in improving market integration. Spatial integration of milk markets, as seen from above, can be improved by the government increasing its attention to provision of physical and institutional infrastructure. Normally good infrastructure can also increase milk production in areas where it is low. Farmers can be enticed to increase production if they see good roads, good communication networks and good market institutions. This is the role of every government in power.

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