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Spatial price transmission: A study of sheep markets in Sudan

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Abstract

Recent research in low-income countries has shown that high transfer costs and marketing margins may hinder the transmission of price signals, as they may prohibit arbitrage. Oligopolistic behavior and collusion among domestic traders may retain price differences between markets at levels higher than those determined by transfer costs and hinder the full price transmission and market integration (Rapsomanikis et al., 2003). This paper investigates price movements among important sheep markets in the Sudan to explore their performance and pricing efficiency. Six geographically separated livestock wholesale markets are tested spatially, using Johansen's cointegration test (1988) and time-series price data for the period 1990–2004. Spatial analysis of the whole dataset indicates the absence of cointegration among the selected markets, while a subset of the data, for the period 2000–2004, after some infrastructural facilities were introduced, shows that the same markets are cointegrated.

Keywords: Sheep markets; Spatial transmission; Cointegration; Sudan

Des études récentes auprès des pays à faible revenu ont montré que les frais de transfert et les marges de commercialisation élevés pouvaient entraver la transmission du signal des prix puisqu'ils pouvaient empêcher l'arbitrage. L'attitude oligopolistique et la collusion parmi les commerçants du pays peuvent maintenir des différences de prix entre les marchés à un niveau plus élevé que celles déterminées par les frais de transferts et gêner la transmission du prix total et l'intégration du marché (Rapsomanikis et al., 2003). Cet article s'intéresse aux mouvements des prix parmi les importants marchés aux moutons au Soudan pour étudier leur performance et leur efficacité en matière de prix. Six marchés de bétail en gros séparés géographiquement sont testés de manière spatiale, grâce au test de cointégration de Johansen (1988) et des données chronologiques concernant le prix pour la période de 1990–2004. L'analyse spatiale de l'ensemble des données indique qu'une absence de cointégration parmi les marchés sélectionnés alors qu'une partie des données, pour la période de 2000-2004, après l'introduction de quelques facilités infrastructurelles, montre que ces mêmes marchés sont cointégrés.

Mots clés : *Marchés aux moutons ; Transmission spatiale ; Cointégration ; Soudan*

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1. Introduction

The livestock subsector in Sudan provides a livelihood for about 14 to 20% of the population. The current (2004) official estimates of the livestock population put the total animal population at about 40, 49, 42 and 37 million head of cattle, sheep, goats and camels respectively (FMAR, 2005). The livestock is concentrated in the Western Sudan States, which have about 39% of the country's total livestock population. Livestock in the Sudan satisfies the internal demand and leaves substantial excess for export, which represents about 22% of the country's total exports and contributes about 19% of GDP (MoF, 2005).

Sheep markets in Sudan lack some basic infrastructural facilities such as paved roads and transport. There are primary markets in the production areas, where the sellers are mainly the producers (the Baggara tribe) and the buyers are the small livestock traders (*gallaga*) and the local butchers. The secondary sheep assembly markets are located far from the production areas, where the sellers are the producers and the *gallaga*, and the buyers are mainly the big livestock traders (*jallaba*) or the brokers (*wakeels*). The middlemen (*sabbaba*) are found anywhere at the primary and the secondary markets. The final or terminal markets are located at the big consumption areas where the sellers are mainly the *jallaba* or the brokers, and the buyers are the wholesale butchers or the sheep and mutton exporters. Generally speaking, the structure of the sheep markets approaches the oligopoly model, where a few buyers dominate. The sheep are mainly transported by trekking from the primary markets to the secondary and seldom by trucking to the final markets. The nominal prices of sheep show severe seasonal movements at all market levels because of transport difficulties during the rainy season.

The producers' marketing decisions are based on market price information, and poorly integrated markets may convey inaccurate price information, leading to inefficient product movements (Goodwin & Schroeder, 1991). The answer to the central question of 'how long an initially localized scarcity can be expected to persist' depends entirely on how well the region is connected by arbitrage to other regions (Ravallion, 1986). Furthermore, the extent of market integration has a great influence on successful agricultural price policy formulation and stabilization.

The starting point for discussing market integration is the existence of separate regions, each with its own supplies and demands for a range of commodities. Because each product has its own supply and demand function, it is possible to identify autarkic prices in each region at each point in time, say P_t^1 and P_t^2, for each homogenous commodity. When free trade across the regions is introduced, the actual prices may differ from the autarky prices. For instance, if the price difference between P_t^1 and P_t^2 exceeds T_t (the transaction cost at time t), profits can be made by shipping commodities from the region with lowest price to the region with highest price. This process will increase demand for the commodity in the region with lowest price, while increasing supply in the market with the highest price. The increase in demand (with unaltered supply) in the market with a low autarky price will drive up the actual price, while the increased supply (at a given level of demand) will decrease the actual price in the region with a high autarky price. This process of arbitrage will persist until actual prices differ by exactly T_t. Markets are said to be integrated if they are connected through such a process of arbitrage.

Gonzalez-Rivera and Helfand (2001:1) state that

> for a market to be called integrated, we require that the set of the locations share both the same traded commodity and the same long-run information. In a cointegration framework,

> this second condition (the long-run information) is equivalent to requiring the existence of one and only one integrating factor that is common to all series of prices.

2. Time series statistical stationarity

Testing for cointegration requires time series data, stationary or non-stationary. A stationary time series is one whose statistical properties, such as mean, variance and autocorrelation, are all constant over time. Non-stationarity (a unit root process) is a property common to many macroeconomic and financial time series data; it means that a variable has no clear propensity to return to a constant value or a linear trend. Their variance is time dependent: it goes to infinity as time goes to infinity. Rapsomanikis et al. (2003) state that

> a non-stationary series has time-dependent statistical properties. Non-stationary series may contain stochastic or deterministic trends. Variables that contain stochastic trends are called 'integrated' and exhibit systematic, but unpredictable variation, as compared to series that contain deterministic trends and display completely predictable variation.

Stationary series, on the other hand, have a finite variance, transitory innovations from the mean, and a tendency for the series to return to its mean value. The value of the mean is time independent.

The non-stationarity or presence of a unit root in any series means that the series embodies integrated data. Testing for cointegration at the first step requires testing the order of stationarity of the variables. Integration tests or unit root tests are a prerequisite for cointegration tests. Thus, an econometric model cannot be specified unless we know the order of integration of the variables. The order of integration (existence or absence of non-stationarity) in the time series in this study was checked by the augmented Dickey-Fuller (ADF) test, which is the most widely used method for unit root tests (Dickey & Fuller, 1979).

To determine the order of integration, the individual t-values of the estimated coefficients are compared to the critical values for the ADF test based on the following null and alternative hypotheses:

$$H_o : P_t \sim I(1) \text{ vs } H_1 : P_t \sim I(0)$$

If the null hypothesis cannot be rejected, then P_t are non-stationary and could be integrated of order one, $I(1)$, or integrated of order two, $1(2\ )$, or even of a higher order. In the event that different series have different orders of integration, we conclude that they are not integrated collectively.

If prices in spatially separated markets (or different levels of the supply chain) p_{1t} *and* p_{2t} contain stochastic trends and are integrated of the same order, say $I(d)$, the prices are said to be cointegrated if

$$p_{1t} - bp_{2t} = u \qquad (1)$$

and u is $I(0)$, b is referred to as the cointegrating vector, u_t is the estimated residual and the equation is known as cointegrating regression. More specifically, p_{1t} and p_{2t} are cointegrated if there is a linear combination between them that does not have a stochastic trend even though the individual series contains stochastic trends, i.e. if u_t is non-stationary, then $p_{1t} - bp_{2t}$ is not a cointegrating relationship.

However, the simple cointegration tests developed by Granger (1986) and Engle and Granger (1987) fail to address linkages between more than two series. This is because these methods were developed in a bivariate framework. To overcome this limitation, a better and more powerful test for cointegration was developed by Johansen (1988) and Johansen and Juselius (1990). This test is particularly important in dealing with cointegration in a multivariate framework.

3. Johansen's cointegration tests

Under Johansen's procedure, cointegration among the price series is tested using Johansen's (1988) maximum likelihood test based on the error correction representation (ECR) or a reduced rank model because the coefficients to be tested should have no full rank. The model is also known as the vector error correction (VEC) model.

The form of the multivariate system is as follows:

$$\Delta p_t = \varphi_1 \Delta P_{t-1} + \cdots + \varphi_{k-1} \Delta p_{t-(k-1)} + \pi p_{t-k} + \mu + \varepsilon_t \quad (2)$$

which can be rewritten as

$$\Delta p_t = \sum_{i=1}^{i=k-1} \varphi_i \Delta p_{t-1} + \pi p_{t-k} + \mu + \varepsilon_t \quad (3)$$

where p_t is $(n \times 1)$ vector of $I(1)$ variable, $\Delta p_t = p_t - p_{t-1}$, φ_i and π are $(n \times n)$ coefficient matrices, (t) is time, $t = 1, 2,\ldots, T$, $k = 1,2,\ldots, t-1$, μ is constant, and ε_t is an error term. The latter two are both $(n \times 1)$ vectors. When there are r linearly independent cointegrating vectors, π could be rewritten as $\alpha\grave{\beta}$, where both α and β are $(n \times r)$ matrices with rank r.

β contains the cointegrating vectors and is $n \times (n-1)$ matrix. According to Jha et al. (2005), Hong and Felmingham (2006) and Siliverstovs et al. (2005), if we have (n) endogenous variables, each with one unit root, there can be from zero to $n-1$ linearly independent cointegration relations, i.e. $r = n - 1$, if the locations share the same long-run information. α is $n \times (n-1)$ matrix of coefficients or adjustment parameters, and is known as the speed of adjustment coefficient of the error correction term. This measures the average speed of convergence of the series in question towards the long-run equilibrium. If α equals zero, then this series does not participate in the adjustment back towards equilibrium and is described as being weakly exogenous.

Johansen's procedure allows us to test the coefficients α and β, using several likelihood ratio tests. In other words, the rank of π in equation (3) equals the number of cointegrating vectors, which is tested by maximum eigenvalue and likelihood ratio test statistics. If there are co-movements between prices, then there is a possibility that they will trend together in finding a long-run stable equilibrium relationship.

For any commodity complexes to be integrated in the true sense, they must share a common trend and therefore should have one common integrating factor. According to Gonzalez-Rivera and Helfand (2001), for there to be a common integrating factor among the integrated prices, all the price series must be cointegrated and the rank *(r)* of π must be *(n -1)*, which should equal the number of cointegrating vectors. In a situation where there are fewer than *(n-1)* cointegrating vectors, there would be more than one common trend. Supposing there are four cointegrating vectors among six non-stationary variables, this would mean that there are at least two common trends. In such a situation, some prices could be generated by the first common trend, some by the second and some by a combination of the first and second trends. Such prices cannot be considered integrated, since the long-run movements in prices would be governed by different components (Kumar & Sharma, 2003).

Johansen's approach estimates the VEC model under various assumptions about the trend or intercept parameters and the number of (*r*) the cointegrating vectors, and then conducts likelihood ratio tests. Assuming that the VEC model errors (ε_t) are independent and normally distributed $N_n [0, \delta^2]$, and given the cointegrating restrictions on the trend or intercept parameters, the maximum likelihood $L_{max}(r)$ is a function of the cointegration rank *(r)*. Johansen (1988) proposes two tests for *(r)*, as follows:

i) The lambda-max test

This is described by the following equation:

$$\lambda_{max}(r) = -TLn(1-\lambda_n)^1$$

This test is based on the log-likelihood ratio $Ln[L_{max}(r)/L_{max}(r+1)]$, and is conducted sequentially for $r = 0, 1,.., k -1$. It tests the null hypothesis that the cointegration rank is equal to *(r)* against the alternative that it is equal to *(r+1)*.

ii) The trace test

$$\lambda_{trace}(r) = -T\sum_{(i=r+1)}^{n} [Ln(1-\lambda_i)]$$

Similarly, the trace test is based on the log-likelihood ratio $Ln[L_{max}(r)/L_{max}(k)]$, and is conducted sequentially for $r = k -1,..., 1,0$. The name comes from the fact that the test statistic involved is the trace of a diagonal matrix of generalized eigenvalues.

The trace test tests the null hypothesis that the cointegration rank is equal to *(r)* against the alternative that it is equal to *(k)*. The latter implies that the trend is stationary. In addition, if the cointegration rank is zero the series are not cointegrated and if the rank is *(k – 1)* the series are cointegrated.

Johansen's maximum-likelihood technique is a multivariate technique; it makes it possible to test more than two series at a time. However, recent work (Rapsomanikis, 2003) has pointed out some deficiencies even in the popular cointegration of the Johansen maximum-likelihood technique. Rapsomanikis's model focuses on switching regime models that incorporate data on prices, volumes traded and transaction cost.

4. Results and discussion

4.1. Market association test results

Table 1 shows the correlation coefficients of the selected markets by using the nominal prices. The correlation coefficients are used to reflect supply and demand in interconnected markets, especially for Um Durman, the main consumption and terminal market, which trades with all the other surplus and assembly sheep markets in the Sudan, and El Obeid and Nyala, between which there is a historical trade link. However, the limitation of correlation analysis is that markets could be correlated for reasons other than co-movement of prices, as for example when there is general inflation.

Table 1: Pearson correlations for the selected markets nominal prices (1990–2004)

Correlations	Um Durman	Medeni	Sennar	El Obeid	Nyala	El Fao
Um Durman	1.000					
Medeni	0.964	1.000				
Sennar	0.956	0.956	1.000			
El Obeid	0.972	0.967	0.953	1.000		
Nyala	0.941	0.959	0.947	0.967	1.000	
El Fao	0.952	0.944	0.925	0.945	0.922	1.000

Source: Field survey data
Note: All correlations are significant at the 1% level.

4.2. Spatial sheep markets analysis

To test for spatial price transmission, time series data on nominal monthly average sheep prices from six geographically separated markets were selected. These were Um Durman, Medani, El Obeid, Nyala, Sennar and El Fao. To eliminate the impact of inflation, the nominal prices were deflated using the consumer price index (CPI), with January 1990 = 100. Altogether there were 180 (15 years) average monthly prices for five markets, and 120 (10 years) average monthly prices for the sixth, El Fao.

Nyala, a surplus market and production area, showed the lowest mean deflated price for the whole period, followed by El Obeid, a surplus and major assembly market. The deficit markets of Um

Durman, Medeni and Sennar showed approximately close mean values deflated prices of about SD3.87, SD3.85 and SD3.83 per head respectively for the years from Jan 1990 to Dec 2004. El Fao, also showed a relatively low deflated mean price as a secondary market. Table 2 shows the statistical characteristics of the deflated prices (SD).[2] Figures 1 and 2 show graphically the variations and trends of the deflated series of the selected markets.

Table 2: Statistical characteristics of the deflated prices (SD), January 1990 to December 2004

Series in log	No. of observations	Max. value	Min. value	Mean
Um Durman	180	4.696	3.330	3.871
Medeni	180	4.499	3.067	3.854
Sennar	180	4.702	3.086	3.835
El Obeid	180	4.477	2.874	3.519
Nyala	180	3.690	2.581	3.104
El Fao*	120	4.006	2.947	3.549

Source: Field survey data
* El Fao price for the period 1995–2004

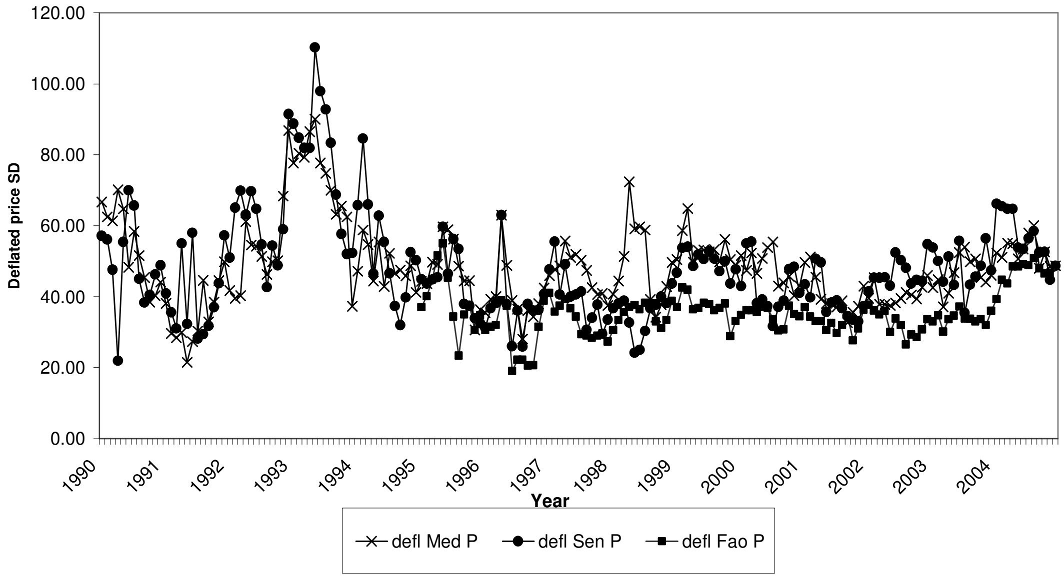
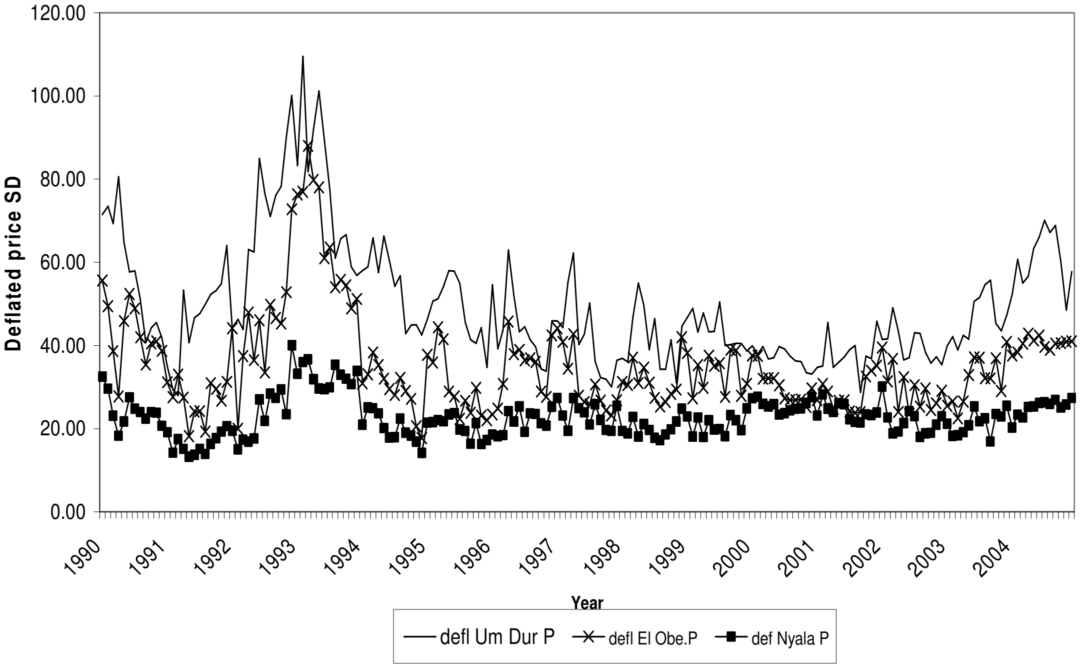


Figure 1: Deflated prices variations of Medeni, Sennar and El Fao

[2] At time of writing (2004), the Sudanese currency was the dinar (SD) and the exchange rate was US$1.0 = SD256.



Source: Field survey data (2005)

Figure 2: Deflated prices variations of Um Durman, El Obeid and Nyala

4.3. Unit root test results

As mentioned above, the first thing to be accomplished in studying spatial relations is to test for a unit root or order of stationarity of the variable in the series. Integrated markets are those whose series show a unit root, and become stationary series after differencing *(d)* times.

The presence or absence of a unit root, i.e. non-stationarity or integration in the price series of the selected markets, was tested by an ADF test. The null and alternative hypotheses are as follows:

H_o: P_t is a unit root, against the alternative

H_1: P_t is a trend stationary process.

The same test was performed, with its null and alternative hypotheses, on the first differences of the price series to see the order of integration. Table 3 shows the results of the unit root test levels and of the first difference of the selected markets for the period 1990–2004. For levels, using ADF, the null hypothesis (presence of unit root) cannot be rejected in the case of the the Um Durman, Sennar and El Fao sheep markets. In the case of the first difference of the series the null hypothesis was rejected, which means that the series became stationary in the first difference. This result indicates that Um Durman, Sennar and El Fao are non-stationary and are integrated of the same order ADF test, while the El Obeid, Nyala and Medeni sheep markets are stationary series. For further confirmation we test for market cointegration for the selected markets.

Table 3: Unit root test results for the selected markets 1990–2004

Series in log	Level test statistics	First difference test statistics
	*ADF	**ADF
Um Durman	-2.318	-3.077
El Obeid	-4.013	-4.065
Nyala	-5.191	-3.771
Medeni	-4.486	-3.264
Sennar	-2.860	-3.669
El Fao	-2.431	-4.398

Source: Field survey data (2005)
* (ADF) levels critical values for H_o: Unit root with drift, H_1: Linear trend stationarity:
< -3.40 (5%), < -3.13 (10%)
**(ADF) first difference critical values for H_o: Unit root H_1,: stationarity around a constant:
< -2.89 (5%), < -2.58 (10%)

5. Cointegration test results

To confirm whether the selected markets are cointegrated, Johansen's maximum likelihood procedure, based on error-correction representation, was used. For the set of the selected markets to be cointegrated, the rank of Π in the equation must be *(n-1)* cointegrating vectors. Johansen's vector auto regression (VAR) was used to find which markets, within the *(n-1)* rank, share the common trend. If there is one cointegrating vector between any two markets, that means these markets share a common trend and are cointegrated. Next, one more market is added. If the additional market shares a common trend with the previous two, then there should be two cointegrating vectors. If only one cointegrating vector is found, that means the additional market does not belong with the two previous markets and is dropped. Then another is added and checked, and so on.

Table 4 shows the results of various market series combinations tested by Johansen's lambda-max (LM) and trace test for the number of cointegrating vectors. The results indicate that the null hypothesis *(r=n-1)* for all series is rejected and the alternative hypothesis that *(r=n)* is accepted, implying that all series are trend stationary, i.e. they do not contain a unit root or share a common trend. The series are thus not amenable for testing by the cointegration procedure, and the sheep markets in question are not cointegrated. Each market seems to operate independently, at least for the period studied (1990–2004).

Table 4: Johansen's lambda-max and trace test for the number of cointegrating vectors, January 1990 to December 2004

Series in log	Null hypothesis	Lambda-max test	Critical* values	Trace test	Critical* values	VAR order
Um Durman,	r=0	59.2	15.8	73	20.2	1
El Obeid	r=1	13.9	9.1	13.9	9.1	
Um Durman,	r=0	63.9	21.9	113.7	35.1	1
El Obeid,	r=1	35.7	15.8	49.7	20.2	
Nyala	r=2	14.1	9.1	14.1	9.1	
El Obeid,	r=0	36.3	15.8	61.5	20.2	1
Nyala	r=1	25.2	9.1	25.2	9.1	
Um Durman,	r=0	35.9	15.8	51.1	20.2	1
Medeni	r=1	15.2	9.1	15.2	9.1	
Um Durman,	r=0	47.5	21.9	97.8	35.1	1
Medeni,	r=1	35.4	15.8	50.2	20.2	
Sennar	r=2	14.8	9.1	14.8	9.1	
Um Durman,	r=0	66.6	21.9	115.4	35.1	1
Medeni,	r=1	35.6	15.8	48.7	20.2	
El Obeid	r=2	13.1	9.1	13.1	9.1	

Source: Field survey data (2005)
* Significant at 5% level.
Note:
1. The tests carried with restrictions imposed on intercept.
2. VAR order was determined by the Hannan-Quinn and Schwarz Information Criteria.

The lack of cointegration among sheep markets perhaps does not come as a surprise or is perhaps not unexpected in the Sudan. The long distances separating the major sheep production areas from the consumption areas, the slow means of transport and communication and the high marketing costs are the main reasons for this phenomenon. The trekking route from Nyala to El Obeid, for instance, is about 600 kilometers, and that between El Obeid and Um Durman is about 560 kilometers, giving a total trekking route from Nyala to Um Durman of about 1,160 kilometers. The journey along this route takes 75 to 80 days, making the total marketing costs about 24% of the total costs. Fafchamps and Gavian (1995), using average monthly livestock prices, studied the spatial integration of livestock markets in Niger. They found that livestock markets are poorly integrated, prices are seldom cointegrated, and there is evidence of market segmentation. They attributed the lack of market integration to the long distances involved and the primitive way animals are transported. They state that

> long distance trade, as opposed to local arbitrage, appears to be what guarantees a modicum of market efficiency. Major long-distance markets play a key role in spreading price movements spatially. Shocks that affect well-established livestock assembly points tend to ripple through the system, while markets located downstream operate as a sink for shocks originating upstream. (1995: 26)

According to Rapsomanikis et al. (2003), in developing countries poor infrastructures, namely transport and communications services, give rise to large marketing margins because of the high costs of delivering the products for consumption. High prices are thus retained at the consumption areas despite their relatively low levels at the production areas, and vice versa.

6. Subsample cointegration tests

To verify the previous results, a subsample of the prices from 2000 to 2004 of the series of the selected markets is analyzed in a similar manner. As there were substantial improvements in the methods of transporting sheep in the Sudan during the period 2000–2004, especially after the partial construction of the western paved road (Kosti to El Obeid to El Khewi), trekking has been replaced by trucking to the consuming areas, especially to Um Durman. This period coincided with the communications revolution in the Sudan through the widespread use of stationary and mobile phone systems.

Table 5 shows the results of the unit root tests for the subsample of the selected markets' deflated prices (January 2000 to December 2004). The results indicate that the ADF values, for all markets except for Sennar, are not large enough to reject the null hypothesis, which means that the series contain unit roots and are non-stationary. The Sennar series contains no unit root and the prices do not move within the series over time. This is because Sennar acts as a small or subterminal market, supplied from the Blue Nile, and there might be a negligible flow of sheep form Sennar northward to the other consumption areas of the capital city.

Table 5: Unit root test results for the sub-sample, January 2000 to December 2004

Series in log	Levels test statistics	First difference test statistics
	*ADF	**ADF
Um Durman	-3.043	-6.471
El Obeid	-2.843	-5.663
Nyala	-3.016	-6.759
Medeni	-2.569	-6.162
Sennar	-3.593	-6.640
El Fao	-1.737	-6.455

Source: Field survey data (2005)
* (ADF) levels critical values for H_o: Unit root with drift, H_1: Linear trend stationarity:
< -3.40 (5%), < -3.13 (10%)
**(ADF) first difference critical values for H_o: Unit root H_1,: Stationarity around a constant:
< -2.89 (5%), < -2.58 (10%)

The first difference analysis results also show rejection of the null hypothesis, which means that there are no unit roots for all series, i.e. the series becomes stationary after the first difference, which indicates that these series are integrated of the same order, *I(1)*.

The subsample was also subjected to cointegration analysis. Table 6 shows the results of the Johansen's lambda-max and trace test for the number of cointegrating vectors for the subsample of the selected markets. The lambda-max and trace values are too small to justify rejecting the null hypothesis *(r=n-1)* for the sets or combinations of the selected markets shown in the table. These series combinations, except for El Fao, show evidence of cointegration. This may be because Medeni as a subterminal market, located on the western bank of the Blue Nile, is supplied from markets within the Gezira State, while the flow of El Fao sheep from the Butana locality is directly transferred to the main terminal Um Durman sheep market.

Table 6: Johansen's lambda-max and trace test of the number of cointegrating vectors for the subsample, January 2000 to December 2004

Series in log	Null hypothesis	Lambda-max test	Critical* values	Trace test	Critical* values	VAR [a] order
[b] Um Durman,	r=0	31.4	14.6	34.7	17.8	1
El Obeid	r=1	3.3	8.1	3.3	8.1	
[b] Um Durman,	r=0	35.5	21.3	54.8	31.3	1
El Obeid,	r=1	16	14.6	19.2	17.8	
Nyala	r=2	3.2	8.1	3.2	8.1	
[c] El Obeid,	r=0	26.2	19.2	39.5	25.4	1
Nyala	r=1	13.3	23.5	13.3	12.5	
[c] Um Durman,	r=0	24.9	19.2	34.5	25.5	1
Medeni	r=1	9.7	23.5	9.7	12.5	
[c.] Um Durman,	r=0	31.3	25.4	52.2	42.4	1
Medeni,	r=1	14.7	19.2	20.9	25.4	
El Fao						
[b] Um Durman,	r=0	18.7	14.6	20.1	17.8	1
El Fao	r=1	1.3	8.1	1.3	8.1	
[b] Medeni,	r=0	14.4	14.6	17	17.8	1
El Fao						
[c] Um Durman,	r=0	41	25.4	72	42.4	1
Medeni,	r=1	21.4	19.2	31.7	25.4	
El Obeid	r=2	10.3	23.5	10.3	12.5	

Source: Field survey data (2005)
* Significance at 5% level.
[a] VAR order is determined by the Hannan-Quinn and Schwarz information criteria.
[b] Analysis carried with restriction imposed on intercept.
[c] Analysis carried with restriction imposed on trend.

7. Conclusions

The results of the spatial price analysis for two distinct time periods for the same set of markets clearly indicated that infrastructural facilities contribute to the cointegration of markets and the transmission of the right price signals. Poor infrastructure, on the other hand, namely transport and communication services, give rise to large marketing margins because of the high costs of delivering products to destinations. They may also hinder the transmission of price signals because of noncompetitive behavior among traders. On the other hand, infrastructural development can play an important role in supporting the integration of livestock markets, facilitating competition, encouraging investment, and allowing a more efficient allocation of resources and enhancing market-oriented production. Infrastructure such as that found in the Sudan's areas of livestock production fails to perform these important functions. For a vast country like Sudan, with livestock exports constituting the second most important source of non-petroleum hard currency earnings, we feel that the government should make it a development priority to invest in roads and communications services to enable this important subsector to realize its potential.

Acknowledgements

This article is part of a thesis submitted by Abdel Gabbar M Abdalla to the University of Khartoum in fulfillment of the requirements of a PhD degree (Agriculture).

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