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Integration between Sheep Markets in the Sudan: A Multivariate Approach

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Abstract

The objective of this study was the investigation comprised the long run equilibrium and the short run dynamic interlinkages between sheep markets by using the monthly data of Omdurman, Medani, Elobied, Nyala and Sennar markets from January 1980 to December 1984 and from January 1990 to December 2000. The main findings were as following (i) The prices were first difference stationary, (ii) The test failed to reject the null hypothesis of no long run relationships between variables in the period 1980-1984 and (iii) there was only one cointegrating vector in the system in the period 1990-2000, and the short run integration appeared to be weak. The long run dynamics was re-examined by using impulse response tests and the results support the cointegration of these markets. It may be interpreted that any shock to the equilibrium relationships is mostly restored within four months lag period. The results also suggested relative leadership of Omdurman and Nyala markets in sheep pricing, which means the system is driven by large markets.

Keywords: Sheep market cointegration; Panel data; Sudan

Introduction

The Sudan sheep population kept increasing. In the year 2002, it comprised 47 million heads. The production of sheep is distributed all over the country with special concentration in the western states, and is of great importance to the Sudanese economy. It is one of the main source of food and income generation as well as important sources of foreign exchange.

The most typical characteristic of a sheep market is that it is a collection market and of seasonal nature. Further, because of agro-climatic needs and seasonality, temporal and interregional price differentials are high. In addition, sheep marketing passes through long market channels that include assembling, transporting and reconditioning. Therefore, the question arises whether the sheep markets are efficient, in terms of conveying price and quantity information from one market to another. The speed and accuracy at which price and quantity information is conveyed also promotes efficiency in resource allocations.

Until recently, correlation coefficient and bivariate regression have been the most common measures used to test market integration. However, the information they can provide is limited. Multivariate analysis offers a more useful, though a less simple alternative. Therefore, following multivariate model were tested for the integration of selected cattle markets in Sudan [1-3]. It provides an interesting and unique case study of sheep markets because of their geographical structure. It is a good starting point to better understand how specific models could be applied; view the efficiency of sheep markets in developing countries; and formulate policies to promote efficiency in sheep markets in Sudan[4].

The general objective of this paper was to evaluate market integration for sheep in Sudan. The specific objectives were (i) to test whether sheep markets are integrated in the short run and (ii) to test whether sheep markets are integrated in the long run.

Methodology

The cointegration model was applied to some main regional sheep markets; of Nyala, Omdurman, Elobied, Medani and Sennar in Sudan. The period of observation is divided into two sub-samples. The first sub-sample spans from January, 1980 to December, 1984 (60 observations), and the second sample covers the period from January 1990 to December 2000 (132 observations). These monthly prices are wholesale prices, i.e., the selling price of a head of sheep measured in Sudanese Dinaries. To avoid spurious regression, the deflated prices are used in a logarithmic form (Figures 1-5).

Markets are cointegrated if a change in one market will cause changes in the other markets, or put more cautiously if changes in markets do not happen independently [5].

The intuitive idea behind the measurement of market integration is to understand the interaction among prices in spatially separated markets [6]. Under certain conditions, and following the structure-conduct-performance approach, the existence of price cointegration, may be viewed as a necessary condition for efficient allocation of resources and hence, maximum welfare [5,7-12] and Munir et al. [12] stated that, market cointegration provides evidence of competitiveness of markets, effectiveness of arbitrage and efficiency of pricing.

To examine the co-movements between sheep markets, Johansen, Johansen and Juselius approach was followed [1,13]. This is a system approach for multiple cointegration analysis, which overcomes many problems of the previous tests. This test enables the testing for and estimation of more than one cointegrating relationship and also permits testing for the validity of any restriction on cointegrating relationships implied by economic theory. The Johansen procedure

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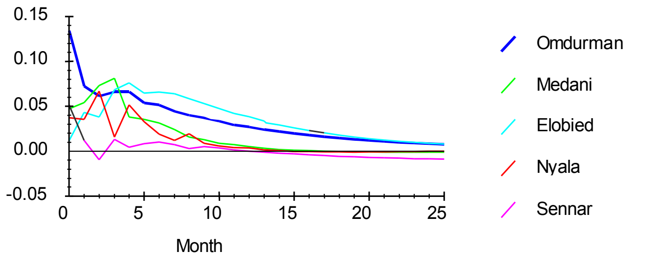

Figure 1: Generalized impulse response to one standard error shock in the equation of Omdurman sheep prices, 1990 to 2000.

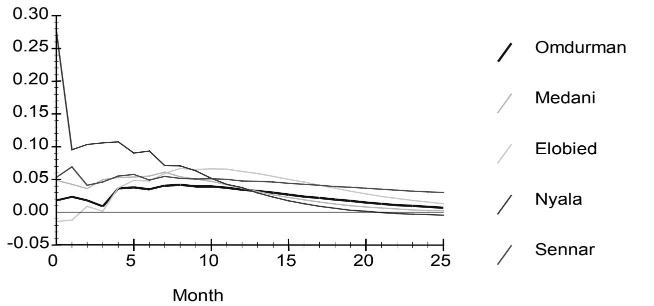

Figure 2: Generalized impulse response to one standard error shock in the equation of Medani sheep prices, 1990 to 2000.

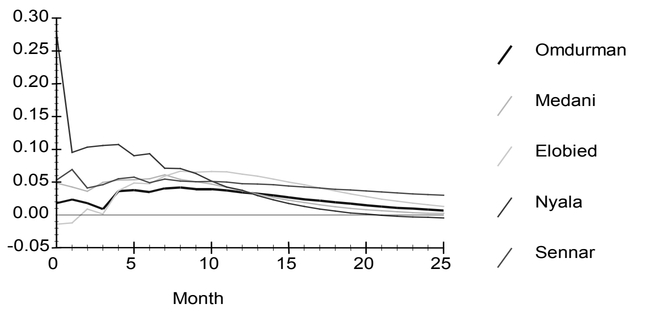

Figure 3: Generalised impulse response to one standard error shock in the equation of Elobied sheep prices, 1990 to 2000.

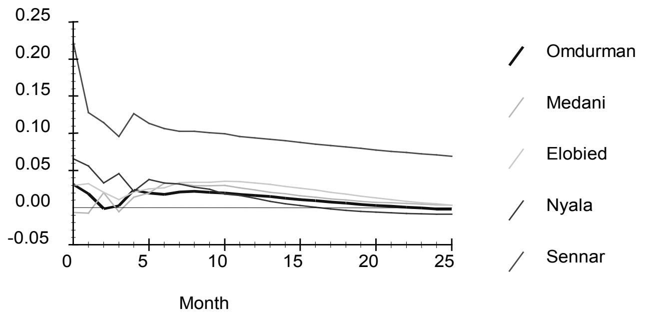

Figure 4: Generalized impulse response to one standard error shock in the equation of Nyala sheep prices, 1990 to 2000.

implies many steps: The first step is to test whether any cointegration relationship exists between prices at separate markets. To do this, vector autoregressive error correction model (VARECM) was used.

This was done through the following steps:

i. Determining the order of the VAR model: The vector autoregressive model of order p which is offered by Microfit program written by [14] is:

$$ {}_{V-1}Z_t = a_o + a_1 t + \Pi Z_{t-1} + \Gamma_i Z_{t-i} + \Psi W_t + u_t \quad (1)$$

For t = 1,2, … n, where:

Z_t is an mx1 vector of the time series concerned i.e $Z_t = (Y_t \text{ and } X_t)$

$Y_t \rightarrow m_y$ =dimensional vector of of endogenous I(1)-series

$X_t \rightarrow m_x$ =dimensional vector of exogenous I(0)-series

a_o = Vector of constants

a_1 = Vector of trend coefficients

t =a vector of linear time trend

$\Pi = m_y xm$- matrix of the long run effect ($m = m_y x m_x$)

Γ_i = is $m_y xm$ coefficient of the short run dynamics

Ψ = is matrix of the coefficient of the exogenous variables

$W_{t=}$ a qx1 vector of exogenous variables and

u_t = mx1 vector of unobserved disturbances.

v = the order of the VAR.

The order of the augmented VAR model, v, can be selected either with the help of model selection criteria such as Akaike information criterion (AIC), Schwartz Bayesian criterion (SBC) or by means of a sequence of log-likelihood ratio tests. Usually, the model with the maximum value of these two criteria would be selected [15,16].

ii. Determining the number of cointegration vectors in the model using the maximal eigenvalue and the trace tests of the stochastic matrix of Johansen. This involves testing whether stable linear combinations exist between the variables in question. If it exists, how many cointegration vectors exist? This test depends on what is called the cointegration regression. If the number of vectors (r) equals zero (r = 0) then no integrating relationship exist and if r<m, then there are r cointegrating relationships and m – r common trends. Assuming the simplicity the cointegrating relationship for the m-dimensional time series vector, Y_t can be represented by the model:

$$\triangle Y_t = \Pi Y_{t-1} + a_t \quad (2)$$

where $\Pi = \alpha \beta$; α and β (mxr)-matrices with the full rank

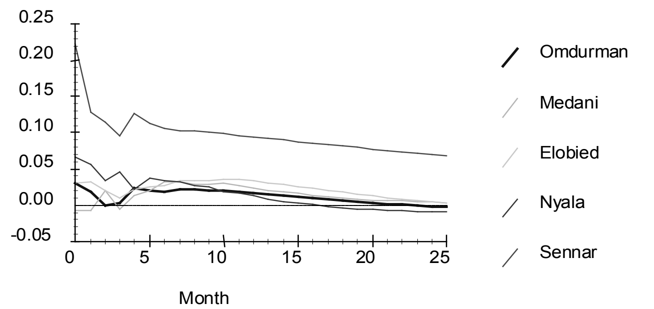

Figure 5: Generalised impulse response to one standard error shock in the equation of Sennar sheep prices, 1990 to 2000.

For testing the hypotheses [14] provides three different tests: Likelihood-ratio (LR)- test, maximal eigenvalue, LR-test, trace test and Model selection criteria AIC, SBC and HQC. The two LR tests first test the zero cointegrating relationships; if that is rejected, it then tests the null hypothesis, that there is only one cointegrating relationship, and proceeds in step-wise fashion to test the null hypothesis of higher number of such relationship up to m-1. With the model selection, criteria r is selected corresponding to the maximum critical value.

It is only meaningful to continue with coingtegration analysis if the choice of r lies between zero and m. If the variables are cointegrated, then we ensure the validity of an error correction representation of the relationship between the variables.

iii. The third step was estimating the dynamic model in an error correction form (ECM). The VECM represents the lagged short run dynamics in addition to the long run equilibrium indicators:

$$\triangle Y_t = a_{oy} + a_{1y}t + \Pi Z_{t-1} + \Sigma \Gamma \triangle Z_{t-i} + \Psi W_t + u_{yt} \quad (3)$$

Where Π is $m_y xm$- matrix of the long run effect ($m = m_y xm_x$)

Γ is $m_y xm$ coefficient of the short run dynamics?

Ψ is matrix of the coefficient of the exogenous variables.

After estimating the ECM for each variable the adequacy of the estimated models could be checked.

The stationarity properties are reported in Table 1 by the unit root testes including (augmented) Dicky-Fuller tests (DF , ADF) and [17,18].

The results of the unit root tests in Table 1 seem reasonable to conclude that Omdurman and Nyala in 1980-1984 period and all price series in 1990-2000 periods were nonstationary in levels and showed stationarity in the first differences. Hence, these series set can be tested for the existence of a long run (cointegration) relationship between them.

In applying the cointegration technique, as a first stage the VAR lag length was chosen using Akaike information criterion (AIC) and Schwartz Baysian and Hannan-Quinn criteria (SBC) [19]. As stated by Persaran [14]. In practice their use (AIC and SBC) often leads to different choices of p; it is up to you to decide the best choice of p for the problem in hand". For the first period, January 1980- December 1984 for sheep prices, when the maximum order for the vector autoregressive (VAR)was set to be 5, the SBC and AIC suggest VAR of the orders 4 and 1, respectively. However, both suggested models

Variable	**Prices in levels**			**Prices in first differences**			
	ADF	**ADF lag**	**P.P**	**ADF**	**ADF lag**	**P.P**	**integration Order**
1980-1984 Period							
Nyala	-1.5756	1^{ASH}	-1.4030	-10.6501	0^{SH}	-14.2653	(1)
Elobied	-7.1247	0^{SH}	-3.0020	-12.4558	0^{ASH}	-13.1586	(1)
Omdurman	-1.2229	5^{AH}	-2.7497	-12.4316	0^{ASH}	-9.5115	(1)
Medani	-5.6436	0^{ASH}	-4.3167	-8.0275	5^{ASH}	-13.6202	(1)
critical value	-3.4935				-2.9168		
1990-2000 Period							
Nyala	-2.6734	2^{ASH}	-3.0066	-4.2154	6^{SH}	-17.3292	(1)
Elobied	-3.7350	0^{ASH}	-3.1577	-13.4561	0^{AS}	-13.1586	(1)
Omdurman	-2.6869	5^{ASH}	-2.7174	-15.1264	0^{SH}	-19.8521	(1)
Medani	-4.2255	0^{ASH}	-3.0783	-10.4840	1^{ASH}	-19.0301	(1)
Sennar	-3.2164	1^{ASH}	-2.3267	-15.4328	0^{SH}	-15.3160	(1)
critical value	3.4461				-2.8847		

The superscripts A, S and H indicate the choice of the Akaike Information, Schwartz Baysian and Hannan-Quinn criteria respectively

Table 1: Unit root tests (DF, ADF and P.P) for sheep prices.

Maximum eigenvalue test			**Trace test statistics**			**Model selection**
H_o	Test statistic	Critical value95%	H_o	Test statistic	Critical value 95%	
r = 0	4.51	15.87	r = 0	6.50	20.18	$r = 0^S$
R = 1	1.98	9.16	$r \leq 1$	1.98	9.16	$r = 1^H$
						$r = 2^A$

The superscripts, A, S and H indicates the choice of the Akaike Information, The Schwartz Baysian and Hannan-Quinn criteria respectively r stands for the number of cointegrating vectors.

Table 2: Johansen tests results for the number of cointegrating vectors, sheep prices January 1980 -Dcember1984.

Maximum eigenvalue test			**Trace test statistics**			**Model selection**
H_o	Test statistic	Critical value 95%	H_o	Test statistic	Critical value 95%	
R = 0	52.61	34.40	r = 0	101.13	75.98	r = 0
R = 1	20.64	28.27	$r \leq 1$	48.52	53.48	$r = 1^{SAH}$
R = 2	14.89	22.04	$r \leq 2$	27.88	34.87	r = 2
R = 3	10.38	15.87	r 3	12.99	20.18	r = 3
R = 4	2.62	9.16	r 4	2.62	9.16	r = 4

The superscripts, A, S and H indicates the choice of the Akaike Information, the Schwartz Baysian and Hannan-Quinn criteria respectively stands for the number of cointegrating vectors.

Table 3: Johansen tests results for the number of cointegrating vectors, sheep prices January, 1990-December, 2000.

are accepted by the log likelihood ratio adjusted for small samples. But, the VAR's of the order 1 and 4, although accepted by LR test, the inspection of individual equations of these VAR's results in significant serial correlation. Since the studied price series were relatively not very long, we have to avoid the risk of over parameterisation, so a VAR of the order 4 is selected.

For the sheep markets in the second period January 1990-December 2000, setting the maximum order to 5, the minimum of both AIC and SBC suggest models of order 4 and 1 respectively. Therefore the VAR of the order one is rejected by the log likelihood ratio adjusted for small samples.

Therefore, the VAR of order 4 is selected for the second period also. Once the choice of the order of the VAR is subject to an important degree of uncertainty, special care needs to be exercised when interpreting the test results. In 1980-1984 period, the multivariate model was applied to Omdurman and Nyala markets only since they were the only econometrically integrated pairs. Johansen tests results for the number of cointegrating vectors are presented in Table 2. The maximum eigenvalue statistic was 4.51 and the trace tests statistic was 6.50, which were well below their corresponding 95% critical values 15.87% and 20.18%, respectively) suggesting that no stable cointegrating relationship exists between the variables in concern. This result is also suggested by the choice of Schwartz Baysian and Hannan-Quinin criteria. Hence it could be concluded that, there is no cointegrating vector between the variables in this period.

As evident in Table 3, both the maximum and the trace eigenvalue statistics strongly reject the null hypothesis that there was no cointegration between sheep markets namely (r=0), but do not reject the hypothesis that there is one cointegrating relation between these variables.

A similar result also followed from the values of the various model selection criteria reported in the last column of Table 3. This complete agreement between the three procedures for testing/selecting the number of cointegrating relation is very rare. Therefore it could be concluded that there is one stable long run relationship between sheep prices in January1990-December 2000 period.

The study proceeded by imposing only one cointegrating vector in the second period. The error correction models (ECM) were estimated and the long and short run matrices were extracted and presented in Table 4. Test on the residuals of the dynamic equations revealed different results with the specification.

These matrices describe the system dynamics. The interpretation of each coefficient separately hurts the system-thinking as all the variables change together in a dynamic system, therefore only the overall tendency could be read.

These cointegration long run equilibrium matrices (Π) were extracted from the error correction models and presented in Table 4. The level of sheep prices in the five markets exerted long run effect on Medani, Elobied and Sennar, but they failed to do so with Nyala and Omdurman markets (Table 4). On the other hand, the presented equations showed the significant cointegration short run dynamics matrices. The short run test results showed that a number of markets are linked not only to each other but also to their own lagged prices.

The ECM equations for current sheep price changes in different markets were as follows:

(i) Omdurman:

$$\triangle O_t = -0.39\triangle O_{t-1} + 0.11\triangle E_{t-3} \quad (3O)$$

(-3.62) (2.07)

(ii) Medani:

$$\triangle M_t = 0.38\triangle O_{t-2} - 0.25\triangle M_{t-2} + 0.45\triangle O_{t-3} - 0.14\,\acute{\varepsilon}_{t-1} \quad (3M)$$

(2.47) (-2.46) (3.13) (-2.18)

(iii) Elobied:

$$\triangle E_t = -0.22\triangle E_{t-1} + 0.28\triangle S_{t-1} + 0.22\,\acute{\varepsilon}_{t-1} \quad (3E)$$

(-2.26) (2.04) (2.60)

(iv) Nyala:

$$\triangle N_t = -0.58\triangle N_{t-1} - 0.33\triangle N_{t-2} \quad (3N)$$

(-5.05) (-2.73)

(v) Sennar:

$$\triangle S_t = 0.36\, S_{t-1} \quad (3S)$$

(4.86)

(The values in parentheses are the t- ratios for the estimates)

The error correction terms in sheep prices in Medani, Elobied and Sennar models were statistically significant suggesting the validity of the long run equilibrium relationships. However, the coefficients of these error correction terms were 14, 22 and 36 percent for Medani, Elobied and Sennar, respectively. This indicates that these models were correcting their previous period disequilibrium by 14%, 22% and 36% a month, respectively.

As clear in these equations, Sennar had no short run linkages with other markets and Nyala was affected by its own prices only (lagged one and two months). It also illustrated in Table 4 Omdurman sheep prices are explained jointly by its own prices for lag one and Elobied for lag three. Also Omdurman lagged two and three months with lagged (two) price of Medani emerged as significant determinants of Medani prices. Elobied and Sennar each lagged one month significantly determine Elobied prices. The diagnostic tests of these error correction models for the sheep prices, with the exception of Omdurman and Medani models show no evidence of serial correlation, and no problem of any non

	$\triangle O_t$	$\triangle M_t$	$\triangle E_t$	$\triangle N_t$	$\triangle S_t$
$\triangle O_t$	0.06 (0.05) (-1.24)	-0.02 (0.02) (-1.24)	0.02 (0.02) (0.96)	-0.04 (0.03) (-1.24)	0.09 (0.07) (1.24)
$\triangle M_t$	-.0.14 (0.07) (-2.18) *	-0.05 (0.02) (-2.18) *	0.04 (0.02) (1.63)	-.0.10 (0.05) (-2.18) *	0.22 (0.10) (2.18) *
$\triangle E_t$	0.23 (0.09) (2.60) *	0.08 (0.03) (2.60) *	-0.08 (0.03) (-2.72) *	0.16 (0.06) (2.60) *	-0.34 (0.13) (-2.60) *
$\triangle N_t$	-0.010 (0.10) (-0.99)	-0.03 (0.03) (-0.99)	0.01 (0.03) (0.34)	-0.07 (0.07) (-0.99)	0.14 (0.15) (0.99)
$\triangle S_t$	0.36 (0.07) (4..86)*	0.13 (0.03) (4..86) *	-0.13 (0.03) (-5.14*)	0.24 (0.05) (4..86) *	-0.54 (0.11) (-4..86) *

*=Significant at p=0.05. △ Denotes the change in a variable in question O=Omdurman; M=Medani; E=Elobied; N=Nyala; S=Sennar.

Table 4: Long run equilibrium matrices (Π) for sheep markets January, 1990-December, 2000.

normality is experienced. Also heteroscedasticity problem is reported only in case of Medani prices Finally, regarding seasonality effect, there was no strong seasonal trend in these sheep prices as it is indicated by the insignificance of the seasonal dummies.

Summary and Conclusions

The investigation covered the long run equilibrium and the short run dynamic interlinkages between sheep markets by using the monthly data of Omdurman, Medani, Elobied, Nyala and Sennar markets from January 1980-December 1984 and from January 1990-December 2000. The main findings are as follows: First, the test failed to reject the null hypothesis of no long run relationships between variables in the period 1980-1984. Second, the Johansen test suggests there is only one cointegrating vector for the five variables in the system in the second period. This result has to be treated with caution. The finding of non or week cointegration in the first period does not exclude the possibility of cointegration in some higher order system that includes more variable such as prices of other important markets e.g. Ghibesh, Sennar and Kosty markets. As Lorenz [20] pointed out the omission or inclusion of certain variables from the cointegration regression can dramatically affect the results obtained from the cointegration regression. In other words, the data period analysed may not be sufficiently long to fully capture the long run relationship. Lastly we re-examined the long run dynamics by using impulse tests and find evidence indicating relative leadership of Omdurman and Nyala markets in sheep pricing which means the system is driven by large markets.

The telecommunications improvement and the liberalisation policy in Sudan may have been the factor that improved the capacity of the livestock sector of responding to new operating environment and improved the extent of price transmission across spatially separated markets. However, the extent of sheep market integration is still low. Market liberalisation by itself cannot achieve a structural change in market integration unless investments in marketing infrastructure (transportation, communication, etc.) are undertaken.

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