Integration between cattle markets in the Sudan, 1980-2000

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ABSTRACT

Long and short run price relationships in Sudanese cattle markets were evaluated in a system of equations using Johansen cointegration and error correction representation procedure with monthly real price data for the period January 1980 – December 2000. Empirical results suggest the existence of a unique long run or equilibrium relationship among cattle prices. The error correction terms were significant, confirming the existence of the long run relationship. A dummy variable capturing the effects of telecommunications improvements and liberalisation polices have emerged as important determinants of cattle prices function. This can be interpreted that, the telecommunications improvement and liberalization policy in Sudan improved the extent of price transmission across spatially separated markets. The error correction models have also been found robust as they satisfy almost all relevant diagnostic tests. The short run and the causality results suggest the lead of Omdurman market, implying that the system is demand driven. The impulse response analysis implied that, in any price shock in any particular area, markets in other areas will respond. However, as implied by the small magnitude of the error correction terms (0.06 - 0.16), the speed of prices adjustment is still low, which implies market liberalisation by itself cannot achieve a structural change in market integration unless more investments in marketing infrastructure (transportation, communication, etc.) are undertaken.

INTRODUCTION

Cattle make a form of productive capital, providing a stream of desired goods and services, including milk, meat, manure and traction. They also serve as an important store of wealth and contribution to the livelihood of farmers and herders and is a source of self-insurance against income shocks. By allocating livestock efficiently over space, spatial market integration should foster a sustainable use of pasture resources. It is also expected to favour the sharing of risk across regions by smoothing price variations. The cointegration models, a blend between economic theory and data properties of economic time series, gained overwhelming popularity in empirical researches. This study contributes to this area by applying the recently developed cointegration technique to cattle market in Sudan.

Markets are cointegrated if a change in one market will cause changes in the other markets, or if changes in markets do not happen independently (Wyeth, 1992). There are many intuitive ideas behind the measurement of market integration. Under certain conditions, 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 (Baulch 1997; Goletti *et. al*., 1995; Palaskas and Harris-White, 1993; Palaskas 1999; Baharumshah and Habibullah, 1994; Williams and Bessler, 1997). Munir *et al*. (1997) stated that market cointegration provides evidence of competitiveness of markets, effectiveness of arbitrage and efficiency of pricing. The overall purpose of this paper is to examine market integration among geographically dispersed cattle markets in the Sudan with an improved methodology. The specific objectives are to determine whether long and short runs relationships exist between cattle prices and to compare price integration in the 1980s and 1990s.

DATA AND METHODOLOGY

The cointegration models were applied to the main regional cattle markets, these are: Nyala, Omdurman, Elobied, Medani. The period of observation for the analysis spans from the first month in 1980 to the last month in 2000 yielding a total of 252 observation per series. These price series are obtained from the records of the Livestock Services Company. To avoid spurious regression, the deflated prices were used in a logarithmic form and the stationarity in each series was assured.

To examine the cointegration in cattle markets, Johansen (1988) and Johansen and Juselius (1990) approaches are used. They present a system approaches for multiple cointegration analysis, which overcome many problems of the previous bivariate tests used in the literature. This test enables the testing of and estimation of more than one cointegrating relationship. It also permits testing for the validity of any restriction on cointegrating relationships implied by economic theory. The Johansen procedure implies many steps:

i. Determining the order of the vector autoregressive model (VAR) model : The VAR model of order v which is offered by *Microfit 4.0* program (Pesaran and Peseran (1997) is:

$$Z_t = a_o + a_1 t + \Pi Z_{t-1} + \sum_{I=1}^{v-1} \Gamma_i Z_{t-i} + \Psi W_t + u_t \qquad (1)$$

For $t = 1,2, \dots n$, where:

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

$Y_t = m_y$ dimensional vector of endogenous I(1)-series (Omdurman, Medani, Nyala and Elobied prices)

$X_t = m_x$ 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.

u_t =is mx1 vector of unobserved disturbances.

m =is $m_y + m_x$

v →is the order of the VAR.

The order of the augmented VAR model, v, can be selected either with help of model selection criteria such as Akaike Information criterion (AIC), Schwarz 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.

ii. Determining the number of cointegration vectors (r) in the model using the maximum eigenvalue and the trace tests of the stochastic matrix of Johansen. This involves testing whether stable linear combinations exist between the variables in concern (Omdurman, Medani, Nyala and Elobied prices). If it exist how many cointegration vectors. This test depends on what is called the cointegration regression represented by the model:

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

The Π in equation 2, is termed the long run impact of the ECM, is of primary importance. First, the rank of Π provides the basis for determining the existence of cointegration or the long run relationship between the variables. According to Johansen (1988) there are three possibilities with regard to the rank of Π:

Case 1 : If rank (Π) is zero, then the variables are not cointegrated.

Case 2 : If zero< rank (Π)> m_y, then the variables are cointegrated.

Case 3 : If rank (Π) = m_y, then the variables are stationary.

Second, the Π matrix can be decomposed into the product of matrices α and β, i.e. Π = α β ; α is the matrix of speed of adjustment coefficients, which characterises the long run dynamics of the system, while β is the matrix representing the cointegrating relations in which the disequilibrium error is stationary (Johansen and Juselius, 1990). For testing the hypotheses about the rank of Π, *Microfit* provides three different tests: Likelihood-ratio (LR)- test, maximum 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, then they test the null hypothesis that there is only one cointegrating relationship, and proceeds in step-wise fashion to test the null of higher number of such relationship up to (m_y-1). With the model selection criteria, (r) was selected corresponding to the maximum critical value.

It is only meaningful to continue with coingtegration analysis 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 is estimating the dynamic model in an error correction form (ECM). The ECM represents the lagged short run dynamics in addition to the long run equilibrium indicators:

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

Where Π is $m_y$xm- matrix of the long run effect (m = m_yxm_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 would be checked through testing the residuals for serial correlaion, the normality, heteroscedastisity and the predictive failure.

In addition to the ECM, the dynamics of the cointegrated system can be investigated *via* the impulse response or dynamic multiplier analysis. The impulse response functions trace out the responses of variables in the system to shocks in the error terms. Both the ECM and the impulse response analysis are used to analyse cattle prices in the following sections.

RESULTS AND DISCUSSION

A VAR of order 9 was selected by the model selection criteria. This result was used to determine the number of the cointegrating vectors in the models based on the maximum eigenvalue, the trace of the stochastic matrix tests of Johansen and the three model selection criteria i.e. HQC, SBC and AIC were used. The results obtained are presented in Table 1. Starting with the null hypothesis of no cointegration (r = 0) among variables, the maximum eigenvalue statistic is 31.22 and the trace of the stochastic matrix statistic is 63.04 which are well above their corresponding 95 % critical value of 28.27 and 53.48. Hence the null of no cointgration is rejected strongly by the two tests. This result is supported by two model selection criteria that is AIC and HQC, but, the SBC says there is no cointegration between these cattle markets. Following the sequential procedure of these tests, both eigenvalue and the trace tests suggest one cointegrating vector between cattle prices in the analysed period. While, AIC says they are two, HQC inflates the result and says they are four. It could be concluded that there is strong evidence regarding the cointegrating vectors, that in cattle markets there is a unique cointegrating vector in the studied period.

Table 1. Johansen tests results for the number of cointegrating vectors (r).

Maximum eigenvalue test			Trace test statistics			Model selection
H_o	Test statistic	Critical value 95%	H_o	Test statistic	Critical value 95%	
r = 0	31.22	28.27	r = 0	63.04	53.48	r = 0 [S]
r = 1	17.06	22.04	$r \leq 1$	31.82	34.87	r = 1
r = 2	8.80	15.87	$r \leq 2$	14.76	20.18	r = 2 [A]
r = 3	5.96	9.16	$r \leq 3$	5.96	9.16	r = 3
						r = 4 [H]

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

Since the result on the number of cointegrating vectors was clear, the study proceeded by imposing only one cointegrating vector. The error correction models (ECM) were estimated and the long and short run matrices were extracted and presented below. These matrices describe the system dynamic. 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. The cointegration long run equilibrium matrices (Π) describe the long run effect presented in Table 2. The level of cattle prices in Omdurman, Elobied, Nyala and Medani exert significant long run effect on the current development of prices of Nyala, Elobied and Medani, but they have no clear long run effect on Omdurman prices.

Cointegration short run significant dynamics matrices (Γ) were presented in the equations (3O, 3M, 3E and 3N) below. The short run test results show that a number of markets are linked not only to each other but also to their own lagged prices. The two matrices (short and long run) showed many significant relationships. These significant relationships in both the long and short run can be rewritten in the form of ECM equations (equation 3) for the four markets as follows:

Table 2. Long run equilibrium matrices (Π), for cattle markets, 1980 – 2000.

	N_t	E_t	O_t	M_t	D
$\triangle N_t$	-0.12*	-0.13*	0.35*	-0.19*	-0.12*
	(-2.87)	(-2.87)	(2.87)	(-2.87)	(-2.65)
$\triangle E_t$	-0.16*	-0.25*	0.66*	-0.35*	-0.21*
	(-3.83)	(-3.83)	(3.83)	(-3.83)	(-3.30)
$\triangle O_t$	0.01	0.02	-0.06	0.03	0.02
	(0.55)	(0.55)	(-0.55)	(0.55)	(0.39)
$\triangle M_t$	-0.06*	-0.09*	0.23*	-0.12*	-0.08*
	(-2.75)	(-2.75)	(2.75)	(-2.75)	(-2.66)

* Denotes the significant coefficients at α 5%.
The figures in parentheses are the t- ratios for the estimates.
△ Denotes the changes in the variable in concern .
N stands for Nyala, E for Elobied, O for Omdurman, M for Medani and D stands for the dummy variable.

(i) The ECM equation for current Omdurman cattle price change:

$$\underset{}{\triangle O_t} = \underset{(-4.60)}{-0.57\triangle O_{t-1}} - \underset{(-4.24)}{0.52\triangle O_{t-2}} - \underset{(-3.08)}{0.38\triangle O_{t-3}} - \underset{(-2.36)}{0.28\triangle O_{t-4}} - \underset{(-2.08)}{0.22\triangle O_{t-6}} \qquad (3O)$$

(ii) The ECM equation for current Medani cattle price change:

$$\triangle M_t = \underset{(-2.45)}{-0.23\triangle O_{t-1}} - \underset{(-3.10)}{0.24\triangle M_{t-1}} - \underset{(-2.16)}{0.18\triangle M_{t-2}} - \underset{(-2.00)}{0.18\triangle O_{t-2}} + \underset{(2.37)}{0.16\triangle O_{t-7}}$$
$$+ \underset{(2.01)}{0.12\triangle O_{t-8}} - \underset{(-2.66)}{0.56D} - \underset{(-2.75)}{0.06\,\acute{\varepsilon}_{t-1}} \qquad (3M)$$

(iii) The ECM equation for current Elobied cattle price change:

$$\triangle E_t = \underset{(2.30)}{0.24\triangle N_{t-1}} - \underset{(-2.06)}{0.39\triangle O_{t-1}} + \underset{(2.77)}{0.43\triangle M_{t-1}} - \underset{(-2.44)}{0.45\triangle O_{t-2}} + \underset{(2.74)}{0.45\triangle M_{t-2}}$$
$$- \underset{(-2.78)}{0.24\triangle E_{t-4}} + \underset{(2.47)}{0.18\triangle E_{t-7}} - \underset{(-3.30)}{0.21D} - \underset{(-3.83)}{0.16\,\acute{\varepsilon}_{t-1}} \qquad (3E)$$

(vi) The ECM equation for current Nyala cattle price change:

$$\triangle N_t = \underset{(-4.49)}{-0.33\triangle N_{t-1}} - \underset{(-2.76)}{0.37\triangle O_{t-1}} + \underset{(3.69)}{0.41\triangle M_{t-1}} + \underset{(2.64)}{0.16\triangle E_{t-1}} + \underset{(2.43)}{0.15\triangle E_{t-2}}$$
$$\underset{(-2.49)}{-0.20\triangle O_{t-8}} - \underset{(-2.65)}{0.12D} - \underset{(-2.87)}{0.08\,\acute{\varepsilon}_{t-1}} \qquad (3N)$$

D stands for the dummy variable which has zero value for the months in 1980-1989 and value of one for the months in period 1990-2000. The figures in parentheses are the t- ratios for the estimates). The short run results showed that, the changes in Nyala prices lagged one month, Omdurman prices lagged one and eight months and Elobied lagged one and two months and the dummy variable (equation3N) emerged to be the significant determinants of the changes in Nyala prices. The changes in Elobied prices are explained jointly by Omdurman which lagged one and two months; Medani lagged one, two and four months whereas, Nyala lagged one month, Elobied lagged four and seven months and the dummy variable (equation 3E). The lagged prices of the other markets do not seem to have significant short run dynamic effect on the changes of Omdurman, nor the dummy variable. Rather, the changes in Omdurman prices were determined by their own prices which lagged one, two, three, four and six months (equation 3O). Omdurman lagged one, two, seven and eight months and Medani lagged one and two in addition to the dummy variable were the significant determinants of the changes in Medani prices in the short run.

In order to select an ECM, it needs to satisfy a range of diagnostic tests. The diagnostic tests for the estimated ECM's usually include Lagrange multiplier test for autocorrelation, Ramsey's "RESET" test for functional form, normality and heteroscedasticity tests. The results of diagnostic tests of the error correction models for cattle prices in Table 3 were robust as they satisfied almost all relevant diagnostic tests. But with the exception of Omdurman, all models suffer from predictive failure problem. One possible explanation for this problem are the characteristics of the data used in the models. When the series were drawn against time it was noticed that the time paths during 1990's were slightly different from previous years. This means that there was a break in the data during 1990's. This is quite understandable because of the instability which has characterised the Sudanese economy during this period. Owing to this problem, the models for predicting the future path of its variables should be used cautiously.

Table 3. Diagnostic tests results for the estimated equations.

	Test statistics					
Equation	R^2	D.W.	A	B	C	D
Omdurman	0.39	1.96	30.01	5.87	23.08	12.37
			(0.003)	(0.015)	(0.000)	(0.000)
Elobied	0.35	2.01	25.02	0.01	58.03	26.81
			(0.015)	(0.943)	(0.000)	(0.000)
Nyala	0.31	2.07	29.37	0.15	61.15	6.95
			(0.003)	(0.694)	(0.000)	(0.008)
Medani	0.47	2.02	15.26	3.21	7.83	8.07
			(0.228)	(0.073)	(0.020)	(0.005)

D.W.: The Durbin Watson test statistic.
R^2 : The coefficient of determination .
A:Lagrange multiplier test of residual serial correlation.
B:Ramsey's RESET test using the square of the fitted values.
C:Based on a test of skewness and kurtosis of residuals.
D: Based on the regression of squared residuals on squared fitted values (The figures between brackets are the rejection probability).

Considering the VAR model of Omdurman, Medani, Nyala and Elobied in cattle prices above, the interest here is to test the significance of a price shock dummy variable which take the value of zero in the 1980's and unity elsewhere, in that model. The results of the log-likelihood ratio statistic for testing the deletion of the dummy from all the four markets equations is 21.15 and it is statistically highly significant justifying the inclusion of the dummy variable in each equation of the VAR. The significance of the dummy in individual market price equations was checked in the previous section. The dummy variable has emerged as significant determinants in case of Medani, Nyala and Elobied, but not statistically significant in case of Omdurman's equation.

Further, to ascertain whether prices respond primarily to supply or demand shocks, the test of Granger non-causality was conducted. If markets located in cattle production areas, tended to Granger-cause prices in major consumption markets, this was taken as evidence that price movements were primarily driven by supply shocks. If, however, terminal markets tended to Granger-cause other markets, this was taken as evidence that price movements were caused by demand shocks. The application of this test to the four-variate VAR in Omdurman, Medani, Nyala and Elobied produced the results in Table 4. In most of the cases, the null hypothesis of non-causality is rejected. An important result is that the others cause Medani and Elobied but neither cause Omdurman nor Nyala. Another important result is that in case of Omdurman, a non-causal relationship is not rejected in one direction, that is from Omdurman to others. Therefore, if there is any transmission of price shocks between these markets, it seems that it goes from Omdurman to the other three markets i.e. Elobied, Nyala and Medani rather than the reverse.

Table 4. LR test of block Granger non-causality in the VAR(9).(H0: no Granger causality)

From	To	LR statistics	Rejection probability
Omdurman	Others	65.00	0.000
Others	Omdurman	35.23	0.133
Medani	Others	37.82	0.081
Others	Medani	52.52	0.002
Nyala	Others	30.70	0.284
Others	Nyala	34.36	0.165
Elobied	Others	36.95	0.096
Others	Elobied	45.97	0.015

In order to gain more insight into the dynamic interrelationships between prices in these markets, the results from the ECM were used to develop impulse response function. The figures below give response functions to a price shock equal in size to one standard error in each market equation over a 25 months horizon. From the graphs (Figures 1-4) of the impulse response analysis, some findings were extracted. First these responses suggest that, after short run adjustments, the prices converge to one another over the long run i.e. after about nine months following the shock. Secondly, if the shock happened in any market, this leads to immediate response in the other markets, but, this immediate response was largest if the shock happened to Omdurman market and slightest if the shock is in Elobied market. Thirdly, this one time only shock leads to that, the shocked market itself keeps depreciating after the shock and the depreciation stops for more than ten months except for Omdurman market which lasts for two months only. In all, the impulse responses were generally in agreement with the previous results and provide strong support for cointegration of these markets.

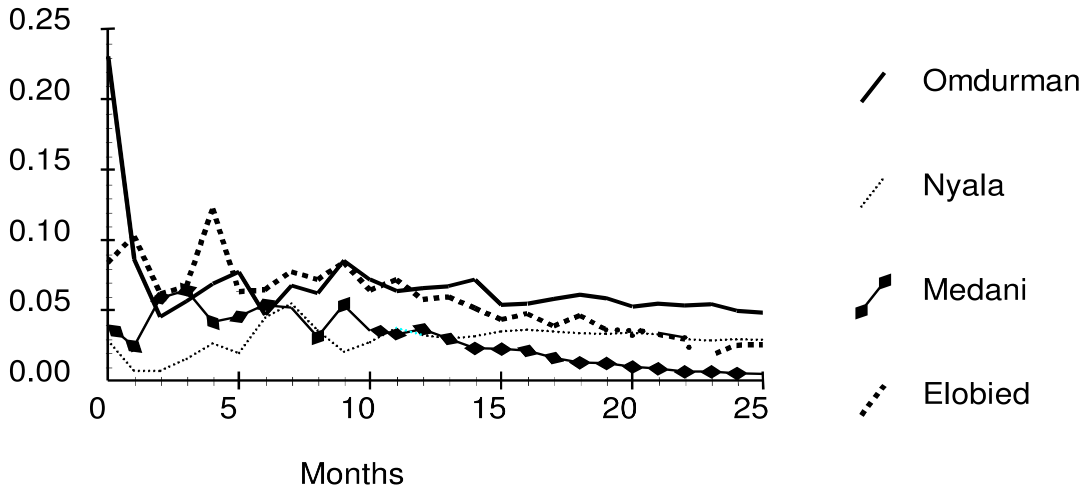

Fig. 1. Generalised impulse response to one standard error shock in the equation of Omdurman cattle prices, 1980 to 2000.

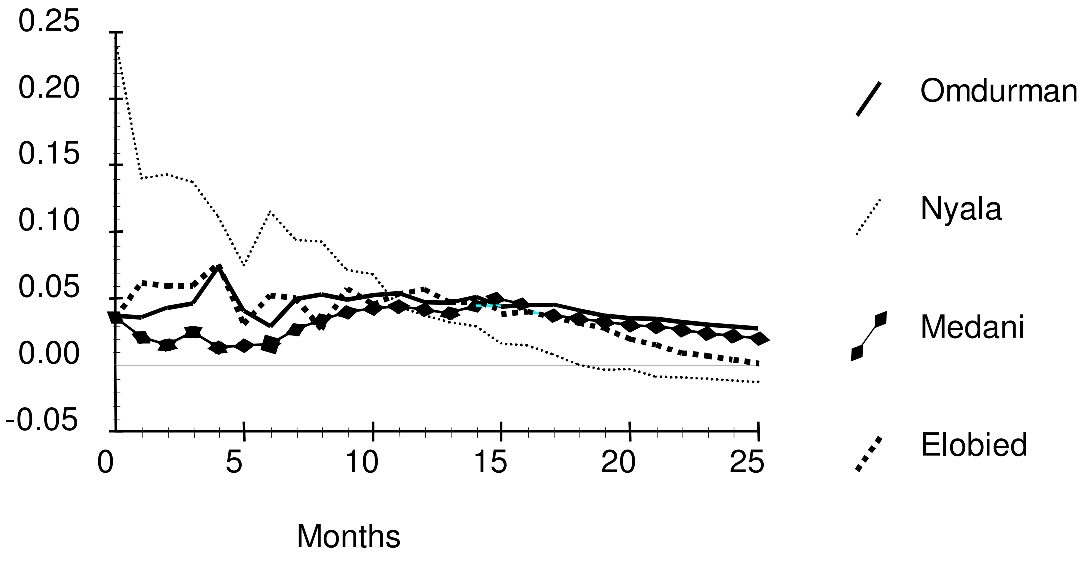

Fig. 2. Generalised impulse response to one standard error shock in the equation of Nyala cattle prices, 1980 to 2000.

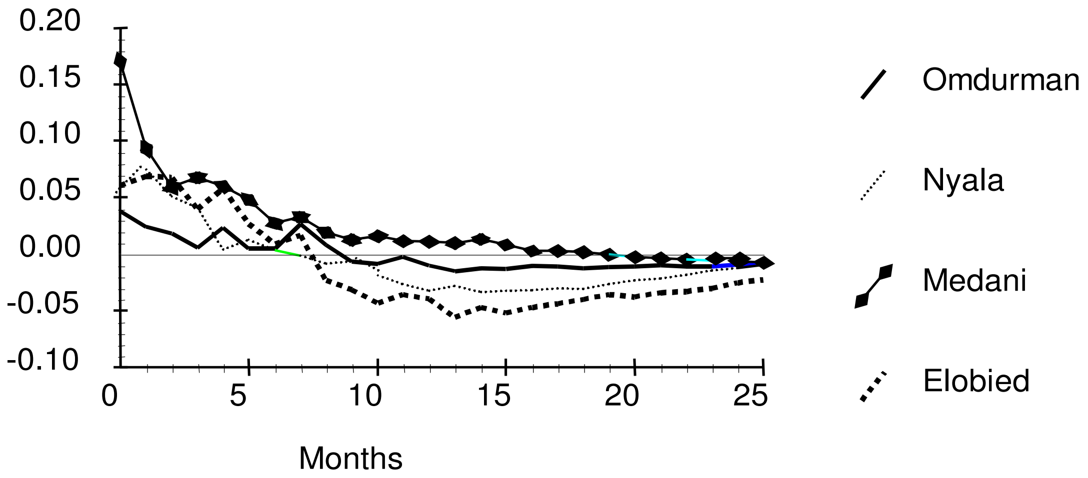

Fig. 3. Generalised impulse response to one standard error shock in the equation of Medani cattle prices, 1980 to 2000.

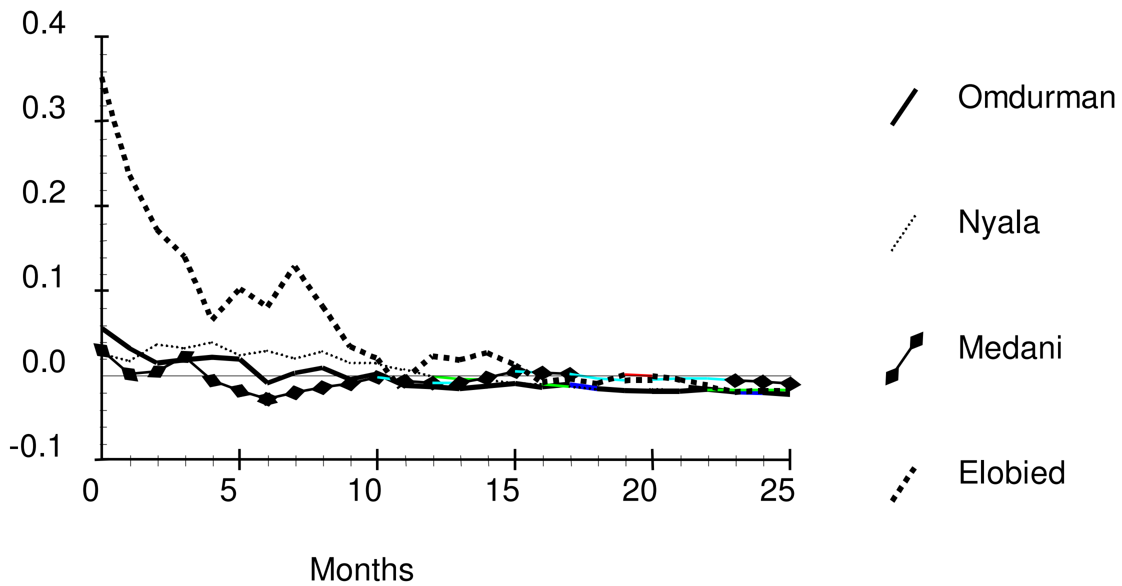

Fig. 4. Generalised impulse response to one standard error shock in the equation of Elobied cattle prices, 1990 to 2000.

CONCLUSIONS AND POLICY RECOMMENDATIONS

Cointegration tests for cattle markets show evidence of long run spatial integration, although less intense in case of Omdurman market. This is an interesting finding which, however, requires further investigation in a number of directions to identify the main reasons for it. One possible reason is the lack of efficient arbitrage or the existence of imperfect competition which makes price discrimination possible. The possible existence of variable transport and transaction costs may also be responsible in certain cases. The second reason is that Omdurman market exerts a large influence in the evolution of others in the short run. This result is consistent with causality and impulse tests. Both evidences are indicating relative leadership of Omdurman market in cattle pricing which means the system is demand driven. This is an interesting result for both policy makers and marketing managers. Marketing managers can use Omdurman as a reference market. Accurate forecast of price evolution in this market will help long term decision making in the rest of cattle markets.

Comparing these results with those obtained by other researchers, there are some differences between their results and the results obtained in this study. Although the measures or formulae may differ from those which were used in this study, all the other studies did not cater for spurious regression and they used nominal prices without deflation. Their results and ours are presented in Table 5.

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التكامل بين اسواق الابقار في السودان، ١٩٨٠-٢٠٠٠

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الخلاصة

هدفت الدراسة إلى معرفة وفهم طبيعة تكامل أسواق الأبقار في السودان. حيث بعد فحص خصائص السلاسل الزمنية للأسعار في هذه الأسواق، استخدمت الدراسة نموذج التكامل المشترك، النموذج متعدد المتغيرات بالإضافة لدراسة السببية والاستجابة للمؤثرات الخارجية. هذه النماذج طبقت على أسعار الجملة الحقيقية الشهرية في أسواق نيالا، الأبيض، مدني و أمدرمان في الفترة من يناير ١٩٨٠ الى ديسمبر ٢٠٠٠. لقد أظهرت الدراسة وجود تكامل بين أسواق الأبقار في المدى الطويل وإن هذا التكامل تحسن فى فترة ١٩٩٠-٢٠٠٠ مقارنة بفترة ١٩٨٠-١٩٩٠ . كما وجد ايضا تكامل بين هذه الأسواق في المدى القصير. بينت الدراسة أيضا أن الزمن الذى تحتاجه هذه الأسواق للرجوع إلي حالة التوازن بعد التعرض للمؤثرات الخارجية، طويل. ولقد اظهر سوق أمدرمان أهمية في توجيه اسعار الأبقار. من هذه النتائج نجد ان تأمين كفاءة استقلال موارد الثروة الحيوانية يتطلب تأهيل البنيات الاساسية لقطاع الثروة الحيوانية.