Efficiency of Selected Sudanese Sheep Markets: A Bivariate Approach (1995-2011)

Mohammed O. A. Bushara[1] and Murtada Kh. A. Abdelmahmod[2]

Abstract

To achieve the objectives of this paper, the following questions were attempted to be answered: 1- Were the sheep prices data in the Sudan had stationarity properties over time? 2- Was there any co integration between these markets in the short and long run?

The data used for this paper covered selected Sudanese Sheep Markets, for the period (1995-2011**).**

The results reveal that the market of sheep affected each other except the sheep prices of Nyala market which separated of other markets excluding Medani. This result seems to be reasonable, because of the recent paved roads that linked between all these markets which accelerated and facilitated the movement between these markets, in addition to a huge capital that specified toward livestock business recently.

Key words: Market efficiency, sheep, bivariate co integration, Sudan

1 Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan.
2 Faculty of Management Sciences and Economics, Department of Economics,University of AL-Butana, Rufaa, Sudan

كفاءة أسواق مختارة للأغنام السودانية: تحليل رقمي (1995-2011م)

عثمان احمد بشارة[1] و مرتضى خالد عبد الله عبد المحمود محمد

المستخلص

لتحقيق أهداف هذه الدراسة، فقد جرت محاولة الإجابة عن الأسئلة التالية:

- هل كانت بيانات أسعار الأغنام في السودان لها خصائص الثبات على مر الزمن؟
- هل هناك تكامل بين هذه الأسواق في المديين القصير والطويل؟

البيانات المستخدمة في هذه الدراسة تُغطي "أسواق الأغنام المختارة للأغنام السودانية" للفترة 1995-2011م. وقد كشفت النتائج أنّ أسواق الأغنام يؤثر بعضها على البعض ماعدا أسعار الخراف لسوق نيالا التي تفصل بينها وبين الأسواق الأخرى مسافة بعيدة لكنها تتكامل مع مدني. هذه النتيجة تبدو معقولة، نظراً للأخيرة فقد مهدت الطرق ذلك الربط بين جميع هذه الأسواق، التي أدت لتسارع وتسهيل الحركة بين هذه الأسواق، بالإضافة إلى رأس المال الضخم الذى حدد لأعمال الماشية مؤخراً.

Introduction:

1.1: Background:

Sudan has become a source country for livestock exports in the beginning of previous decades. Sudan livestock include heads of sheep, cattle, goats and camels in large numbers. Sudan livestock not only provide a livelihood for much of the population it also contributes to GDP. Sudanese beef is considered one of the best with excellent taste because Sudan cattle are reared in healthy conditions, conforming to international certification, and in natural grazing fed with organic food (Bushara and Abdelmahmod 2015).

Sudan is among the richest African countries in term of size of its national herds. The livestock population keeps increasing through the years, in the year 2010 the livestock population comprised about 42 million cattle, 4.623million camels, 52 million sheep and 43million goats as presented in table 2 below:

Table (1): Livestock Population (000 head) 1995-2010

Year	Cattle	camel	sheep	Goats
1995	30077	2903	37146	33319
1996	31669	2915	37202	35215
1997	33102	2936	39835	36037
1998	34584	2974	42363	36498
1999	35825	3031	44802	37346
2000	37093	3108	46095	38548
2001	38325	3203	47043	39952
2002	39479	3342	48136	41485
2003	39669	3503	48440	42030
2004	39760	3724	48910	42179
2005	40468	3908	49797	42526
2006	40994	4078	50390	42756
2007	41138	4238	50651	42938
2008	41426	4406	51067	43104
2009	41563	4521	51555	43270
2010	41761	4623	52079	43441

Source: (Statistics, 2009).

Sudan's economy is one of the fastest growing in the world. Since 1999, the country is taking advantage of vast oil reserves receiving large inflows of foreign direct investment. Yet, in spite of abundance of natural resources (gold, silver, chrome, asbestos, manganese, gypsum, mica, zinc, iron, lead, uranium, copper, kaolin, cobalt, granite, nickel and tin) agriculture remains an important sector of the economy as it contributes a third of GDP. More importantly, years of civil wars, lack of infrastructure, and a reliance on subsistence agriculture has made the majority of Sudanese to live below the poverty line(Bank, 2003b).

The main livestock production sites are located far from the major consumption centers and export outlets. Economically valuable livestock populations are concentrated in northern, western and southern Kordofan and Darfur. Blue Nile and Elgadarif states are also important supply places for export sheep(Bank, 2003a).

Allocating livestock efficiently over space should foster a sustainable use of pasture resources. It is also expected to favour the sharing of risk across regions by smoothing price variation. Thus, studying cointegration of livestock is important for optimal resource use, early warning and market and trade policy,(N.M. Babiker & M. O.A Bushara, 2006).

Livestock have historically been central to Sudan's overall economy, although in recent years oil production has become the dominant feature of the political economy of Sudan. Since 1999, livestock and livestock products (meat, hides and skins) have comprised approximately 20 percent of Sudan's annual Gross Domestic Product (Sudan, 2010). As oil production has increased, however, the relative importance of livestock and livestock product for exports as foreign exchange earners had declined. In 2005 oil was 82 percent (by value) of total exports while livestock and livestock product exports were just 3.2 percent(Sudan, 2010). The International Monetary Fund attributes the recent decline in livestock exports to "supply constraints (inadequate capacity at the port, deterioration in the road infrastructure), conflict in livestock-rich areas, and higher domestic demand"(Fund, 2006,).

Most researchers agree that the problems of livestock marketing in Sudan are limited to the specific problems which can be summarized in a weak infrastructure especially in the area of transport and veterinary services, lack of finance led to oligopoly and oligopsonyin the trade, areas of production distant from areas of consumption and together with lack of suitable transport render animals weak and meat quality low, smuggling especially across the borders to Egypt and Libya and lack of veterinary services.

One of the main problems of livestock marketing is that, the structure of the livestock markets approaches is the oligopoly model, where a few sellers dominate. The sheep, goats, cattle and camels are mainly transported by trekking from the primary markets to the secondary and seldom by trucking to the final markets. The nominal prices of animals show severe seasonal movements at all market levels because of transport difficulties during the rainy season.
According to(B. Idris, 2008), the main constraints to animals marketing include poor marketing infrastructure, lack of marketing organization, lack of market intelligence, absence of marketing extension services and absence of grades and standards.
The choice made by pastoralists and traders in moving animals from pasture to terminal markets and slaughterhouses are conditioned by the context to which they make decisions (N.M. Babiker & M. O.A Bushara, 2006). The main problems indicated by the herders include shortage of drinking water, spread of animals' diseases, and lack of veterinary services and encroachment of agricultural activities on grazing land.(Sakr & Abdel Majid, 1998).

Environmental condition e.g. rainfall and forage availability affect livestock productivity and there for animals' value. Infrastructure conditions affect the cost borne by pastoralists and traders in moving their animals (N.M. Babiker & M.O.A. Bushara, 2006).

According to(Rapsomanikis, Hallam, & Conforti, 2006) 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.
In spatially integrated markets the competition will ensure that a unique equilibrium is achieved where local prices in regional markets differ by no more than transportation and transaction costs. Information of spatial market integration, thus, provides indication of competitiveness, the effectiveness of arbitrage, and the efficiency of pricing (Sexton, Kling, & Carman, 1991).
For a market to be called integrated, that required the set of the locations share both the same traded commodity and the same long-run information. Spatial price relationship is an important indicator of overall market performance. If price changes in one market are fully reflected in alternative market, these markets are said to be spatially integrated(Goodwin & Schroeder, 1991).

Markets that are not integrated may convey inaccurate price signal that might distort producers marketing decisions and contribute to inefficient product movement (Goodwin & Schroeder, 1991) and traders may exploit the market and benefit at the cost of producers and consumers.
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., 2006).

1.2: The problem statement:

The main constraints to animals marketing include poor market infrastructure, lack of market organization, lack of market intelligence, inadequacy of market finance, shortage of drinking water, spread of animals diseases, and lack of veterinary services and transport services, these constraints are affecting marketing efficiency. Information of spatial market integration provides indication of competitiveness, the effectiveness of arbitrage, and the efficiency of pricing, however, markets that are not integrated may convey inaccurate price signal that might distort producers marketing decisions and contribute to inefficient products.
The analysis of livestock integration, cointegration and market efficiency of previous Sudanese studies was mostly conducted by using statistical framework which does not consider the property of the data. These approaches used correlation coefficient and Ordinary Least Square (OLS), which lead to spurious regression. On the other hand, most of these studies do not consider cattle, sheep, goat and camel together. So the results miss the comprehensiveness to livestock markets in Sudan. The contribution of this study to the area of livestock markets studies is the consideration of the sheep and using panel data in the statistical framework.
This paper studies price integration and cointegration among important livestock markets in Sudan to investigate their prices efficiency, referring to efficiency criteria means namely integration and cointegration of market prices.

To achieve the objectives of this study, the following questions need to be answered:
1- Were the sheep prices data in the Sudan had stationarity properties over time?
2- Was there any cointegration between these markets in the short and long run?

1.3: The objectives of study:

The main objective of this study is to investigate price efficiency among selected important sheep markets in the Sudan.

Specific sub-objectives are distinguished:
1- To clarify the sheep price efficiency with reference to selected sheep Markets in the Sudan.
2- To outline some policy recommendations, that might help policy makers to draw plans to improve the sheep marketing system.

2: Data and Methodology:

The paper study scrutinized the markets of sheep in the Sudan. The paper compared the prices of five sheep markets which were Nyala, Medani, Elobied, Sennar and Omdurman. The data for this paper extended from January 1995 to December 2011. Monthly prices were used and being collected from the Animal Resources Corporation, these prices were wholesale prices i.e. the selling price of a head of animal measured in Sudanese Pound (SDG)(Corporation, 2010).The prices were deflated and naturally logged using GDP deflator base year 1994.See Figure (1) below for visual assessment

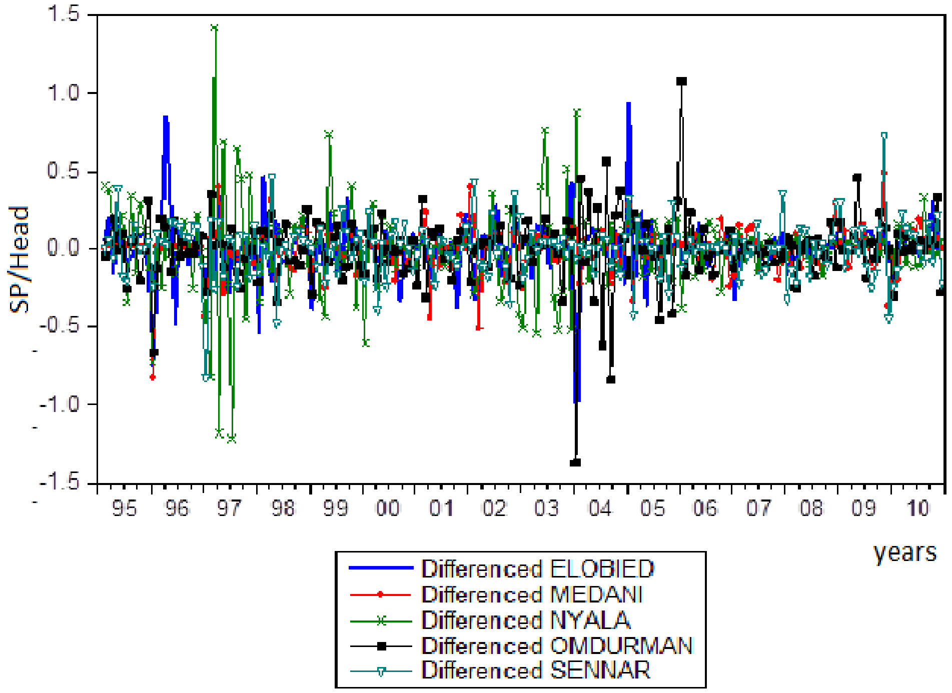

Figure (1): first difference of monthly deflated wholesale price (Sudanese pound per head) of sheep in the selected markets, January 1995- December 2011

Then cointegration testing was carried to specify the order of the variable stationarity. Unit root test for Integration is a prerequisite for cointegration. Thus, the model of econometric could be specified to recognize the order of variables integration. This was done by the Augmented Dickey-Fuller(Dickey & Fuller, 1981) (ADF) and Phillips, P.C. and P. Perron (Phillips & Perron, 1988) tests, which are known methods. According to(Babiker, 2006), in testing cointegration two conditions must be fulfilled: first the data series must have similar statistical properties, because a variable with a constant mean cannot explain movements in a variable whose mean is changing through time. The second condition for cointegration is that there should be some linear combination between the data series. If and only if the hypothesis of no cointegration is rejected an error correction model (ECM) would be estimated to integrate the dynamics of short run (changes) with long run (levels) adjustment process.

2.1: Engle and Granger Approach:

The Engle-Granger residual-based test for cointegration is the following Equation:

$Y_{t1} = \alpha + \beta Y_{t2} + u_t$ …………………………………………………………..…… (1)

Where Y_{t1} and Y_{t2} are the two price series and u_t is the error term. This model called cointegration regression.

Under the null hypothesis of no integration of the series, all linear combinations including the residuals from OLS, are unit root nonstationary. Therefore, nonstationary against the alternative of stationarity was proved. Accordingly, Engle-Granger test uses a parametric, augmented Dickey-Fuller(Dickey & Fuller, 1981) (ADF) approach to accounting for serial correlation in the residual series.

The Engle-Granger test estimates a p-lag augmented regression of the form

$\Delta\hat{u}_{1t} = (\rho - 1)\,\hat{u}_{1\,t-1} + \sum_{j=1}^{p} \delta j\,\Delta\hat{u}_{1\,t-j} + v_t$ …………………………………………… (2)

Where u_t represents the residual of OLS regression, $\Delta\hat{u}_{1t}$ is the difference of residual and p is then number of lagged differences chosen to remove any evidence of serial correlation in the residuals. Two standard ADF test statistics consider, the one based on the τ-statistic (tau) for nonstationary to test the null hypothesis ($\hat{\tau}$) and the other based directly on the normalized autocorrelation coefficient ($\hat{z}$):

$$\hat{\tau} = \frac{(\hat{\rho}-1)}{se(\hat{\rho})} \quad \ldots\ldots (3)$$

$$\hat{z} = \frac{T(\hat{\rho}-1)}{(1-\sum_j \delta j)} \quad \ldots\ldots (4)$$

Where *se (ρ)* is the usual OLS estimator of the standard error of the estimated $\hat{\rho}$. The null hypothesis (H_0) of no cointegration in equation (4) is $\rho = 1$ and the alternative one (H_a) is $\rho < 1$. The lag length in the model was determined using Akaike Information(Akaike, 1987) and Bayesian model selection criteria(Schwarz, 1978), and then the estimate ADF statistic compared with the critical values:

If $ADF_{cal} > ADF_{critical}$ reject H_0: u_t is stationary, and then Y_{t1} and Y_{t2} are cointegrating.

If $ADF_{cal} \leq ADF_{critical}$ accept H_0: u_t is not stationary, and then Y_{t1} and Y_{t2} not cointegrated. If the null hypothesis of cointegration was rejected i.e. long run relationship exists between the variable, an error correction model (ECM) developed by Engle and Granger(Engle & Granger, 1987)would be estimated, it considers bivariate market cointegration between any pairs of markets i and j. The probability values were derived from the Davidson and MacKinnon(Davidson & MacKinnon, 1993) response surface simulation results

Error correction model (ECM) is a time series model in first differences that contains an error correction term, which works to bring two *I(1)* series back into long-run equilibrium,(Wooldridge, 2002). To learning about a potential long-run relationship between two series, the concept of cointegration enriches the kinds of dynamic models at our disposal. If y_t and x_t are I(1) processes and are not co integrated, a dynamic model might be estimated in first differences as considered in the following derivation.

2.2: Driving Error Correction model (ECM):

Assuming the following two variables cointegration regression model:

$$Y_t = \alpha + \beta X_t + u_t \quad \ldots\ldots (5)$$

The Engle-Granger residual-based test for cointegration is simply unit root test applied to the residuals obtained from OLS estimation of the above Equation in two steps:

Step (1) regress Y on X in level to obtain the cointegration vector which is the predicted equilibrium relationships.

From step (1), $u_t = (Y_t - \alpha - \beta X_t)$ =the error term.

This is prerequisite inference. If and only if u_t is stationary, we can proceed to step (2). If u_t is not stationary then the Y,X relationship is spurious, not cointegrating.

Step (2) modify the model in (5) to be:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \beta_0 X_t + \beta_1 X_{t-1} + u_t \quad \ldots\ldots (6)$$

Assume Y_t and $X_t \sim I(1)$.

Subtract Y_{t-1} from both sides of equation and get:

$$\Delta Y_t = \alpha_0 + \rho_1 Y_{t-1} + \beta_0 X_t + \beta_1 X_{t-1} + u_t$$

Where $\rho_1 = (\alpha_1 - 1)$

Now add: $\beta_0 X_{t-1} - \beta_0 X_{t-1}$ and get:

$$\Delta Y_t = \alpha_0 + \rho_1 Y_{t-1} + \beta_0 \Delta X_t + \theta_1 X_{t-1} - \beta_0 X_{t-1} + u_t \quad \ldots\ldots (7)$$

Where $\theta_1 = (\beta_1 + \beta_0)$

If ΔY_t stationary, Y_t and X_t cointegrated, then u_t must be I(0) as well. Now from equation (5) the error term $u_t = (Y_t - \alpha - \beta X_t)$ then $u_{t-1} = (Y_{t-1} - \alpha - \beta X_{t-1})$ which is the error correction mechanism, then the error correction model is:

$\Delta Y_t = \alpha_0 + \beta_0 \Delta X_t + \pi(Y_{t-1} - \alpha - \beta X_{t-1}) + e_t$

Then $\Delta Y_t = \alpha_0 + \beta_0 \Delta X_t + \pi\, u_{t-1} + e_t$ …………………………………………. (8)

This equation (8) implies the last step of Engle and Granger cointegration test,(Engle & Granger, 1987) and accordingly;

Coefficient on ΔX_t will tap short-run effect.

Negative coefficient on u_{t-1} will be error correction.

In equation (8) $\pi<0$. If $y_{t-1} > \beta x_{t-1}$, then yin the previous period has overshot the equilibrium because $\pi<0$, the error correction term works to push *y* back toward the equilibrium. Similarly, if $y_{t-1} > \beta x_{t-1}$, the error correction term induces a positive change in y back toward the equilibrium..

3: RESULTS and DISCUSSON

3.1: Unit Root Tests for Sheep Prices:

Unit root tests were performed on bivariate time series in order to test the order of integration. If time series are found to be individually integrated of the same order after the unit root tests, then these variables may be cointegrated. The test stationarity of monthly logged and deflated sheep markets prices, considered in this paper (Nyala, Medani, Elobied, Sennar and Omdurman), are used from the year 1995m1 to the year 2011m12. To do this, three approaches were applied to prices. These are {(Dickey & Fuller, 1979) and its augmentation (DF/ADF) test,(Dickey & Fuller, 1979, 1981; Phillips & Perron, 1988) procedure and panel unit root test using the E-views software computer program(Startz, 2009).

3.1.1: The Dickey-Fuller (DF) and its Augmented (ADF) Unit Root Test Results:

Table (2 below explains that, the null hypothesis of Elobied market case was accepted in case of the prices in level at the three models while the null hypothesis rejected for the prices series in first difference at the three models too, that according to comparison between ADF statistic values and the critical values in which were found that the ADF statistic values were less than the critical values for the prices in level in absolute term for all models.

Table (2): ADF Unit Root Test for sheep price (levels and First Differences) in Elobied market (1995-2011)

Variables	Model Specifications	Lag length	Levels		First Differences	
			ADF test statistic	Test critical	ADF test statistic	Test critical values
Elobied	No intercept No trend	0 1 2 3 4	0.01727 SIC -4.28396 -3.85163 -3.20685 -3.50008	-1.94243	-11.2408 SIC 5.01136 4.24851 3.51776	-2.57664
	With intercept No trend	0 1 2 3 4 Constant	-1.48633 SIC -3.17169 -3.01819 -2.61161 -3.07307	-2.87684	-11.2208 SIC 5.00860 4.24722 3.51680	-3.46324

			1.52709		0.34982	
	With intercept and trend	0 1 2 3 4 Constant trend	-1.25287 SIC -3.35504 -3.20181 -2.77919 -3.21889 0.65277 1.40739	-3.43257	-11.3829 SIC 5.18834 4.40722 3.64448 -1.25065 1.61979	-4.00484

- SIC stand for(Schwarz, 1978) Schwarz Bayesian information criteria.
- Source: Author calculation using E-Views software computer programs.

The ADF statistic values in three models in level (model with no trend and no intercept, model with intercept and without trend and model with intercept and trend) were (0.01727), (-1.486329) and (-1.25287) which were less than the critical values (-1.94243), (-2.87684) and (-3.43257) respectively, but in case of the first difference test, the ADF statistic value was greater than the critical value in absolute term.

Hence it could be concluded that the price series were non-stationary in case of level but they were stationary in case of first differences. The lag length was selected according to Schwarz(Schwarz, 1978) Bayesian information criterion which chooses four lag in cases of test in level for all models and three lag lengths in cases of test in first difference.

Table (3): ADF Unit Root Test for sheep price (levels and First Differences) in Omdurman market (1995-2011)

Variables	Model Specifications	Lag length	Levels		First Differences	
			ADF test statistic	Test critical values	ADF test statistic	Test critical values
Om-durman	No intercept No trend	0 1	-0.57960 HQC -4.97537	-1.94241	-20.09552 HQC	-2.57646
	With intercept No trend	0 1 Constant	-2.93329 HQC -4.04018 2.87599	-1.87568	-20.04657 HQC 0.121142	-3.46483
	With intercept and trend	0 1 Constant trend	-2.90726 SIC -4.05026 2.39250 0.51168	-3.43223	-20.02405 SIC -0.46767 0.60678	-4.00413

- SIC stand for Schwarz Bayesian and HQC stand for (Hannan & Quinn, 1979) information criteria.
- Source: Author calculation using E-views software programs.

Table (3) above explains Omdurman market case. The null hypothesis was accepted for the prices in level in the three models. The first and the second models were selected according to

Hannan-Quinn information criteria (Hannan & Quinn, 1979)(HQC) with one lag length, while the last model chosen by Schwarz Bayesian information criteria with one lag length.

On the other hand, all models in first differences had rejected the null hypotheses test at 1% significant level on the basis of ADF statistic values, which exceed the critical values in absolute term, so the price series were stationary in first differences, while they were not in the level. The lag length for the price series in first differences was selected according to (Hannan & Quinn, 1979)information criteria for the first model (with no intercept and no trend) and second model (with intercept and no trend) with zero lag for all two models. The last model (with intercept and trend) chosen by Schwarz Bayesian information criteria with zero lag length.

According to table (4) below, the first and third models of Medani market were non stationary in level. The first model chosen by Akaike with two lag length while the third model determined using (Schwarz, 1978) Bayesian information criteria with four lag length. The decision made in view of the ADF statistic values compared with the critical values in absolute term. The first model accepted the null hypothesis for the test in level while it rejected the null hypothesis in case of first differences.

Table (4): ADF Unit Root Test for sheep price (levels and First Differences) in Medani market (1995-2011)

Variables	Model Specifications	Lag length	Levels		First Differences	
			ADF statistic	critical values	ADF statistic	critical values
Medani	No intercept No trend	0 1 2	-0.95957 AIC -3.11148 -2.05034	-1.94242	-10.7168 AIC 2.81159 1.94416	-2.57658
	With intercept No trend	0 1 2 Constant	-3.86404 SIC 3.73717	-2.87561	-10.7038 SIC 2.819473 1.949944 -0.43883	-3.46307
	With intercept and trend	0 1 2 3 4 Constant trend	-2.57285 SIC -2.73943 -2.10984 -1.85596 -1.22336 1.92204 0.60105	-3.43257	-9.64308 SIC 3.38375 2.64897 1.66895 -1.98529 1.98830	-4.00484

- AIC stand for Akaike, SIC for Schwarz Bayesian information criteria.
- Source: Author calculation using E-views software computer programs.
- The second model (with intercept and no trend) was significant at 5% level for

the test in level. Therefore, the price data was stationary because the critical value (-3.86404) exceed the ADF statistic value (-2.87561) in absolute term. The model determined using Schwarz Bayesian information criteria with two lag length. The test in first differences rejected the null hypothesis at 1% significant level in all models. The ADF statistic values (-10.71681), (-10.70375) and (-9.64308) exceed the critical values (-2.57658), (-3.46307) and (-4.00484) in absolute term indicating stationarity of data in first differences. According to the test in level appear non stationary in the first and third models that because the ADF statistic values (-

0.95957) and (-2.57285) less than critical values (-1.94242) and (-3.43257) respectively at 5% significance level in absolute term.

Sennar market in Table (5) below rejects the null hypothesis for the tests in level at 1% significant level in the second and third models, that according to the comparison between ADF statistic values and the critical value which indicates that the ADF statistic values {(-4.19122) and (-5.22760)} were greater than the critical value {(-3.46274) and (-4.00390) respectively} in absolute term in two cases.

Table (5): ADF Unit Root Test for sheep price (levels and First Differences) in Sennar market (1995-2011)

Variables	Model Specifications	Lag length	Levels		First Differences	
			ADF statistic	critical values	ADF statistic	critical values
Sennar	No intercept No trend	0 1 2 3 4	-0.20399 AIC -4.41760 -2.98412 -2.68261 -1.75278	-1.94243	-9.95365 AIC 3.55322 2.82421 1.770317	-2.57664
	With intercept No trend	0 1 2 Constant	-4.19122 HQC -1.88919 4.17578	-3.46274	-11.0923 HQC 3.12815 2.28116 0.29276	-3.46307
	With intercept and trend	0 Constant trend	-5.22760 SIC 4.97934 -0.85591	-4.00390	-17.9575 SIC -0.07731 0.20832	-4.00413

- AIC stand for Akaike,(Akaike, 1981) SIC for Schwarz Bayesian and HQC stand for Hannan-Quinn information criteria.
- Source: Author calculation.

Hence it could be abstracted that the price series were stationary in Sennar market. The first model was non stationary in level according to the comparison between ADF statistic values and the critical value which indicates that the ADF statistic values (-0.20399) was less than the critical value of (-1.94243) in absolute term.

With respect to the test in first differences in all models the null hypothesis was rejected at 1% significant level. So the ADF statistic values exceed the critical value in absolute term indicating stationarity of data in first differences.

The first model was selected according to (AIC) information criteria(Akaike, 1981)with four lag length in case of the test in level and three lag length in case of the first difference. While in case of the second model the lag length was selected according to (Hannan & Quinn, 1979) (HQC) information criteria with one lag length in case of the test in level and two lag length in case of first difference. The third model chosen by using Bayesian information criteria(Schwarz, 1978)with zero lag length in case of the test in level and in case of first difference.

Concluding this, the data of sheep prices in Sennar market were stationary for test in level and first difference except the model without intercept and trend which was non stationary at %5 significant level.

With regard to Nyala market mentioned in Table (6) below, all the models determined by using Schwarz Bayesian information criteria chosen two lag length for the test in level, while the test in first difference the Schwarz Bayesian information criteria determined one lag for all models.

According to Table (6) below, all the models were appeared non stationarity for the test in level and stationarity in first difference when comparing between the test statistic and critical values were done. See Table (6). That the ADF statistic values less than the critical values in absolute term in case of the test in level and the opposite is true in case of the first difference Idris and Abdallah(B. A. Idris, A M, 2009) studied Spatial price transmission of sheep markets in Sudan and they found that Omdurman, Sennar were non-stationary and are integrated of the same order ADF test, while the El Obeid, Nyala and Medani sheep markets were stationary series.

Table (6): ADF Unit Root Test for sheep price (levels and First Differences) in Nyala market (1995-2011)

Variables	Model Specifications	Lag length	Levels		First Differences	
			ADF test statistic	Test critical values	ADF test statistic	Test critical values
Sennar	No intercept No trend	0 1 2	-0.78789 SIC -5.83202 -2.89200	-1.94242	-14.49074 SIC 3.01646	-2.57652
	With intercept No trend	0 1 2 Constant	-2.39675 SIC -4.74181 -2.33841 2.26690	-2.87575	-14.4550 SIC 3.01212 0.16601	-3.46290
	With intercept and trend	0 1 2 Constant trend	-2.33349 SIC -4.79258 -2.38635 1.24145 0.92326	-3.43234	-14.4962 SIC 3.05528 -0.84151 1.05923	-4.00437

- SIC stand for Schwarz Bayesian information criteria.
- Source: Author calculation using E-views software computer programs.

3.1.2: The Phillips Peron (PP) Unit Root Test for Sheep Prices:

In both the PP and ADF unit root tests the null hypothesis is that the series is nonstationary. The test was applied to each individual series of sheep prices in selected market (Medani, Elobied, Omdurman, Sennar and Nyala markets) and the result was presented in the following Table (7).

According to the Table (7 below, the null hypothesis was rejected in case of test in first differences because the PP statistic value exceed critical value in absolute term in all markets, therefore, the price series in these cases are said to be stationary. For test in level the PP statistic value less than the critical value in absolute term except in case of Sennar market.

Table (7): The Phillips Peron (PP) Unit Root Test for sheep price (levels and First Differences) in selected markets (1995-2011)

Variables	Levels		First Differences	
	Phillips-Perron test statistic	Test critical values	Phillips-Perron test statistic	Test critical values
Elobied	-3.94546	-4.00390	-36.5103	-4.00413
Omdurman	-3.87090	-4.00390	-21.05583	-4.00413

Medani	-3.32521	-4.00390	-23.73162	-4.00413
Sennar	-4.97552	-4.00390	-25.00208	-4.00413
Nyala	-3.87118	-4.00390	-34.54911	-4.00413

- Source: Author own calculation using E-Views software computer programs.

Table (8) below reports the final result considering the model without constant and trend for individual sheep price in level.

Table (8): The Phillips Peron (PP) Unit Root Test for sheep price (levels and First Differences) for the model without intercept and trend in selected markets (1995-2011)

Variables	Levels		First Differences	
	Phillips-Perron test statistic	Test critical values	Phillips-Perron test statistic	Test critical values
Elobied	-0.21726	-1.94239	-24.42834	-2.57646
Omdurman	-0.64577	-1.94239	-20.79535	2.57646
Medani	-0.99429	-1.94239	-19.85834	2.57646
Sennar	-0.01184	-1.94239	-24.81397	2.57646
Nyala	-0.93288	-1.94239	-28.02607	2.57646

- Source: Author own calculation using E-Views software computer programs.

With regard to the result above the sheep price series were non-stationary because the tests statistic values less than the critical values in absolute term in all cases. Therefore the null hypothesis was accepted and the price series is non-stationary in level.

3.1.3: The Panel Unit Root Test for sheep prices:

Panel unit root tests provide an overall aggregate statistic to examine whether there exists a unit root in the pooled cross-section and time series data and judge the time series property of the data accordingly(M. O. A. a. A. Bushara, MKA, 2015; M. Bushara & Abdelmahmod, 2015). Therefore, the panel-based unit root tests have higher power than unit root tests based on individual time series(M. Bushara & Abdelmahmod, 2015).

Three panel unit root tests would be used, which were the(Levin, Lin, & Chu, 2002)(LLC)test(Levin et al., 2002), Fisher-ADF test(Crowder, 2003) and(Fisher, 1932) test. The null hypotheses for (LLC) test assume common unit root process, while the null hypotheses for the Fisher-ADF and Fisher-PP tests assume individual unit root process. The results for the test in levels and first differences are reported in Table (9) below:

Table (9): The Panel unit root test (in levels and First Differences) in selected markets (1995-2011)

Tests	Levels		First Differences	
	test statistic	the p-values	test statistic	the p-values

Levin, Lin and Chu	-1.2150	0.1122	-33.6556	0.0000
ADF - Fisher	7.89840	0.6388	624.697	0.0000
PP - Fisher	8.26881	0.6026	775.210	0.0000

- Automatic lag length selection based on SIC.
- Source: Author calculation, using E-Views software computer programs(Startz, 2009).

It's clear that from table (9) in case of level test, all the results indicate the presence of a unit root, as mentioned by the Levin-Lin and Chu (LLC)(Levin et al., 2002)and both Fisher-ADF(Crowder, 2003) and (Fisher, 1932)Fisher-PP tests. The p-values for these tests were (0.1122), (0.6388) and (0.6026) respectively, so these tests fail to reject the null of a unit root. In other hand, in case of first differences test the null hypothesis was rejected in all three tests according to the p-values (0.0000), (0.0000) and (0.0000) for the Levin-Lin and Chu (LLC) (Levin et al., 2002)and both Fisher-ADF (Crowder, 2003)and Fisher-PP tests which indicating the stationarity of data series.

From the three unit root tests applied in this section, it's clear that all price series are non-stationary in level, while it was stationary in first differences for all variables. From these results it could be concluded that all prices were integrated of order I (1).

3.2: Bivariate residual based approach (Engle & Granger, 1987):

For Engle-Granger test, two standard ADF test statistics consider, the one based on the τ-statistic (tau) for testing the null hypothesis of no stationarity and the other based directly on the Normalized Autocorrelation Coefficient ($\hat{z}$). The lag length in the model was determined using Akaike Information and Schwarz Bayesian model selection criteria, and then the estimated ADF statistic compared with the critical values.

3.2.1: Cointegration Regression results for sheep prices:

The Engle–Granger method involves firstly running a cointegration regression of one variable on another, and secondly checking whether the regression residual from the first step is stationary using ADF test. Table (10) below reports twenty pairwise regression results for sheep prices in the selected markets. Estimated parameters (constant- explanatory) are presented with corresponding *p*-value between two brackets for t-ratio. Goodness of fit (R^2) and cointegration Durbin-Watson statistic (CRDW) also was presented in table (11) below. From the table in all cases $R^2 < DW$ which means that, they do not suffer any spurious regression. According to Granger and Newbold (1974), an $R^2 > DW$ is a good rule of thumb to suspect that the estimated regression is spurious(Gujarati, 1995).

With regard to the goodness of fit (R^2) for these relationships, it ranged between 3% low in case of Omdurman on Sennar and 48% high in case of Elobied on Omdurman relationship. According to Omdurman on Elobied, were integrated at 5% significant level, the sign is positive which means that an increasing of Elobied prices increases Omdurman market prices, the goodness of fit of this model indicates that the variability in the prices of Omdurman market explained by 47% of Elobied prices variability.

Omdurman on Sennar relationship was significant at 5% level in the positive direction, which means an increase in Sennar sheep prices increases Omdurman market prices. The goodness of fit illustrates 6% of variability in Omdurman prices caused by Sennar market variability. Medani on Elobied was significant at 5% level and the direction is positive which means that an increasing in Elobied prices leads to an increase in Medani sheep prices. Generally speaking in all four cases the direction between the two markets is positive which means that an increasing of sheep prices in one market leads to increase of sheep prices in the other market.

Table (10): Cointegration regression result for sheep prices 1995M1- 2011M12

Dependent variable	Independent variable	Parameter estimates		R^2	CRDW
		constant	Explanatory		
Elobied	Omdurman	0.301645 (0.0111)	0.664072 (0.0000)	0.476783	0.738898
Elobied	Medani	0.183555 (0.3251)	0.656644 (0.0000)	0.354935	0.505639
Elobied	Sennar	0.137793 (0.5701)	0.738934 (0.0000)	0.213787	0.507989
Elobied	Nyala	0.821628 (0.0000)	0.451785 (0.0000)	0.281066	0.688750
Omdurman	Elobied	0.326406 (0.0182)	0.894185 (0.0000)	0.471051	0.736511
Omdurman	Medani	0.502256 (0.0450)	0.579944 (0.0001)	0.207412	0.423029
Omdurman	Sennar	0.814141 (0.0127)	0.422921 (0.0431)	0.057914	0.347819
Omdurman	Nyala	1.059015 (0.0000)	0.405978 (0.0000)	0.143275	0.538673
Medani	Elobied	0.834518 (0.0000)	0.650650 (0.0000)	0.327322	0.385737
Medani	Omdurman	1.025120 (0.0000)	0.435633 (0.0005)	0.177786	0.308914
Medani	Sennar	0.568702 (0.0153)	0.711331 (0.0001)	0.195816	0.276075
Medani	Nyala	1.204420 (0.0000)	0.456480 (0.0000)	0.329883	0.493907
Sennar	Elobied	1.045864 (0.0000)	0.386398 (0.0002)	0.219389	0.619417
Sennar	Omdurman	1.287428 (0.0000)	0.171035 (0.0455)	0.060790	0.497542
Sennar	Medani	0.919845 (0.0000)	0.372007 (0.0003)	0.230128	0.531788
Sennar	Nyala	1.428022 (0.0000)	0.110326 (0.1165)	0.032563	0.515891
Nyala	Elobied	-0.144898 (0.0000)	0.900921 (0.0000)	0.278937	0.711500
Nyala	Omdurman	0.117017 (0.4757)	0.604859 (0.0002)	0.146712	0.571220
Nyala	Medani	-0.572441 (0.0282)	0.947119 (0.0000)	0.354349	0.639010
Nyala	Sennar	0.404266 (0.3100)	0.388453 (0.1291)	0.032839	0.404190

- CRDW is the cointegration regression Durbin-Watson.
- The figures in parentheses in column 3 and 4 stand for p-values of t-ratio.
- Source: calculated from Appendix (B) using E-Views software program.

3.2.2: The Engle-Granger results for sheep prices:

Once the cointegration properties were found in price series, the second step to the Engle-Granger test is the residuals stationarity test. The Engle-Granger residual-based test for cointegration and the results reported in Table(11) below. The Engle-Granger residual-based tests for cointegration essential on two standard ADF test statistics, the first one based on the τ-statistic (tau) no stationarity and the other based directly on the normalized autocorrelation coefficient ($\hat{z}$). The lag length in the model was determined automatically using Akaike

Information and Schwarz Bayesian model selection criteria which is available in E-Views software program.
As it's obvious from table(10) above that all residuals stationarity tests were rejecting the no stationarity and accept that all the residuals from OLS regression were stationary and therefore, the above relations were long run, and then the error correction model (ECM) would be estimated to integrate the dynamics of short run with long run adjustment process.

Table (11): Engle-Granger(Engle & Granger, 1987) cointegration results for sheep prices in selected markets, 1995M1- 2011M12

	Models	Engle-Granger tau-statistic	Engle-Granger z-statistic	Residuals Stationarity Test
1	Elobied on Omdurman	-6.462781 (0.0000)	-71.65794 (0.0000)	-0.352995 (0.0000)
2	Elobied on Medani	-4.038433 (0.0000)	35.40654 (0.0000)	-0.204964 (0.0000)
3	Elobied on Sennar	-5.085163 (0.0000)	-47.79141 (0.0000)	-0.235426 (0.0000)
4	Elobied on Nyala	-4.296129 (0.0033)	-39.43435 (0.0005)	-0.240897 (0.0000)
5	Omdurman on Elobied	-4.758181 (0.0006)	-45.87788 (0.0001)	-0.274240 (0.0000)
6	Omdurman on Medani	-3.348238 (0.0523)	-22.90333 (0.0264)	-0.146984 (0.0010)
7	Omdurman on Sennar	-3.110645 (0.0907)	-19.89327 (0.0511)	-0.125066 (0.0021)
8	Omdurman on Nyala	-3.695844 (0.0211)	-27.70571 (0.0088)	-0.176671 (0.0003)
9	Medani on Elobied	-5.074155 (0.0002)	-40.90269 (0.0004)	-0.203229 (0.0000)
10	Medani on Omdurman	-3.796700 (0.0158)	-23.45104 (0.0234)	-0.142049 (0.0002)
11	Medani on Sennar	-4.030854 (0.0078)	-23.38964 (0.0237)	-0.140531 (0.0001)
12	Medani on Nyala	-3.760768 (0.0175)	-22.81660 (0.0269)	-0.177762 (0.0002)
13	Sennar on Elobied	-6.061543 (0.0000)	-62.28603 (0.0000)	-0.306828 (0.0000)
14	Sennar on Omdurman	-5.323347 (0.0001)	-50.34979 (0.0000)	-0.248029 (0.0000)
15	Sennar on Medani	-5.738685 (0.0000)	-55.57667 (0.0000)	-0.273777 (0.0000)
16	Sennar on Nyala	-5.408675 (0.0001)	-51.84207 (0.0001)	-0.255380 (0.0000)
17	Nyala on Elobied	-4.129679 (0.0057)	-34.69450 (0.0016)	-0.225864 (0.0001)
18	Nyala on Omdurman	-3.763501 (0.0174)	-29.95367 (0.0052)	- -0.189248 (0.0002)
19	Nyala on Medani	-2.970591 (0.1221)	-20.01297 (0.0498)	-0.164023 (0.0033)
20	Nyala on Sennar	-2.564773 (0.2557)	-14.81731 (0.1461)	-0.112586 (0.0111)

- The values in parentheses are p-values.
- Source: Author calculation, using E-Views software computer program(Startz, 2009).

3.2.3: Estimation of Error Correction Models (ECM) for Sheep Prices:

The results of error correction model, using residuals from the cointegration regressions, are summarized in the Table (12) below. This table illustrates the estimation of the error correction coefficients in the ECM model represented in estimated coefficients and ρ-values of t-test. These estimates have been calculated for two essential variables as indicated in equation (4), the first variable is the first differences of independent variable (appear as D(independent variable in the table)) and the second variable is the error term (appear as RESID(-1) in the table). The estimates of first differences of independent variables and the error term have very important

implications; estimated coefficient for the first differences of independent variable refers to the analysis of the short run while the estimated coefficient of the error term refers to analysis of the long run. At the rest of the table displayed some statistical indicators which were R-squared and Durbin-Watson statistic of the estimated relationship.

According to estimated coefficients for ECM (coefficient of RESID (-1)), there were seventeen models significant at 1% level and associated with the desirable negative signs. Durbin-Watson statistic values close to 2 in all models suggesting the absence of autocorrelation problem.

The models that were not significant were Omdurman on Sennar, Nyala on Omdurman and Nyala on Sennar. This finding suggested that the trend of Sennar sheep prices did not adjust to the shocks of Omdurman and Nyala prices in the long run, on the other hand the prices of sheep in Omdurman market did not adjust to the shocks of Nyala prices in the long run, might be the far distance and the problems of livestock transportation were breaking down the prices affect.

- The values in parentheses are p-values.
- Source: Author calculation.

In view of table (13) Elobied on Omdurman model is significant and adjusted 14% (the value of ECM coefficient) of disequilibrium in the previous period between these two markets.

Based on Table (12), the coefficients for ECM were fluctuated between 5% low and 15% high and significant at 1% level, suggesting that the last period (one month) the prices of Medani on Sennar were corrected in the next month by 5%, where it was adjusting slowly towards the long-run equilibrium. However, Omdurman on Elobied prices in the last period (one month) disequilibrium were corrected in the next month by 15%. However both values seem to be adjusted slowly towards the long-run equilibrium. This implies that any shock that forces prices from their long-run value will take a long time for prices to return to its equilibrium.

The short-run effect presented by the coefficient of independent variables in these models, which appear positive signs and significant in most cases. Five models appear non-significant in the short run, which were Omdurman on Nyala, Sennar on Nyala, Nyala on Elobied, Nyala on Omdurman and Nyala on Sennar depending on p-values (0.1339, 0.7676, 0.5159, 0.1196 and 0.8330 respectively)

This finding shows that Nyala market prices do not have any impact on the rest of the (N.M. Babiker & M. O.A Bushara, 2006) found that the sheep prices of Nyala market are affected by their own prices only in the short run.

The positive signs suggest that the short-run changes in independent market have a positive impact on short-run changes in dependent market with the value of coefficient. The degree of impact fluctuated from model to other, the largest found in Elobied on Omdurman, Elobied on Medani, Omdurman on Elobied, Medani on Sennar and Sennar on Medani (33%, 44%, 34%, 36% and 46% respectively). Interpretation of these finding in the short-run the market prices of Elobied affected the market prices of Omdurman sheep market by 33%, Elobied affect Medani by 44%, Omdurman affect Elobied by 34%, Medani affect Sennar by 36% and Sennar affect Medani by 46%. This coherent effect of sheep market may be due to the active commercial movement between these markets.

The simple cointegration test developed by(Engle & Granger, 1987) failed to address linkages between more than two series. This is because these methods were developed in a bivariate framework. To overcome this limitation, a more powerful test for cointegration was developed by (Johansen, 1988). This test is particularly important in dealing with cointegration in a multivariate framework. The Maximum Likelihood procedure (Johansen's test), suggested by (Johansen, 1988, 1991), is preferable when the number of variables in the study exceeds two variables due to the possibility of existence of multiple cointegrating vectors. The advantage of Johansen's test is not only limited to multivariate case, but it is preferable than Engle-Granger approach even with a two-variable-model (Gonzalo, 1994). Therefore the dynamic test of Johansen (1988 and 1991) was applied to the sheep prices data.

3.3: Concluding Remarks:

Considering the three tests of the unit root applied in this paper, it was clear that all price series were non-stationary in level, while they were stationary in first differences for all variables. From these results it could be concluded that all prices were integrated of order *I* (1).

The long run behaviour of sheep prices in selected markets indicated, evidence of existence of cointegration of pairs of sheep markets. The error correction coefficients in the ECM equations were significant at 1% level and associated with the desirable negative signs in all cases (see figure (2) below).

The results suggested that the trend of Sennar sheep prices did not adjust the shocks of Omdurman and Nyala prices of sheep market in the long term, at the same time the Omdurman prices of sheep not adjusted the shocks of Nyala prices in the long term. May be the far distance gap between these markets and the problems of sheeps transportation were the cause.

The coefficients of ECM were moving between 5% low and 15% high and significant at 1% level, suggesting that the last period (one month) in prices of Medani on Sennar, disequilibrium for example, corrected in the next month by 5%, where it was adjusting slowly towards the long-term equilibrium, On the other hand, with respect to Omdurman on Elobied prices relationship, the last period (month) disequilibrium in prices corrected in the next month by 15%.

In the short term the prices of Nyala sheep market did not have impact on the other market prices, and it did not be affected by any other sheep market prices, (N.M. Babiker & M. O.A Bushara, 2006) found that the sheep prices of Nyala market were affected only by their own prices in the short term. The prices of sheep in Elobied market affected the sheep market prices of Omdurman by 33% in the short term, Elobied affected Medani by 44%, Omdurman affected Elobied by 34%, Medani affected Sennar by 36% and Sennar affected Medani by 46%. Theses effects of sheep prices might be due to the improvement of communication and transportation between these markets as well as to the relatively small distances between them.

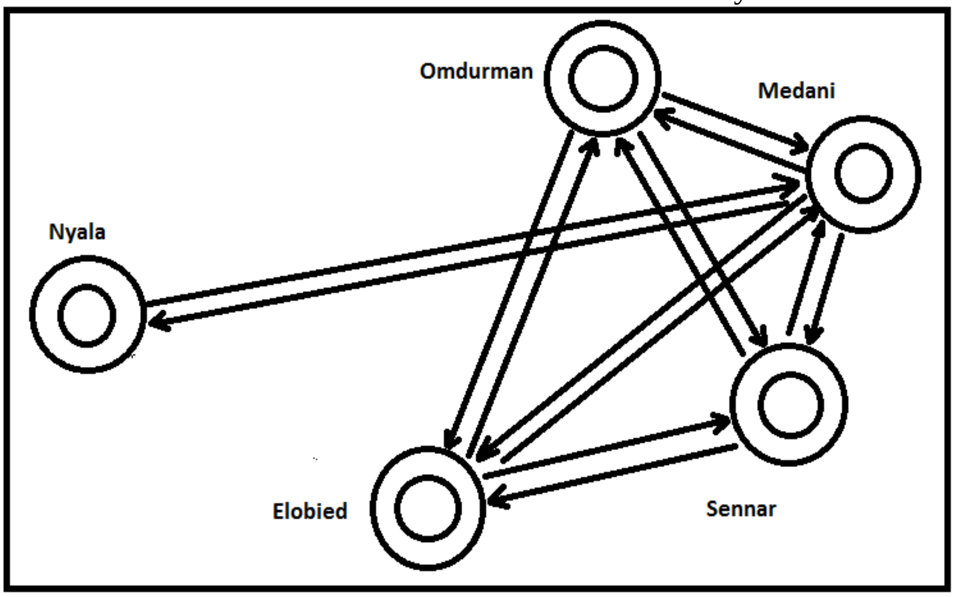

Figure (2): Lines connected bivariate sheep markets whose prices were cointegrated in the short run, 1995m1- 2011m12

Source: Drawing using Estimated Error Correction Table (13).

Figure (1) above reveals that the prices of sheep markets affected each other except the sheep prices of Nyala market which separated of other markets excluding Medani. This result seems to be reasonable, because of the recent paved roads that linkage between all these markets which accelerated and facilitated the movement between these markets, in addition to a huge capital that specified toward livestock business recently. This result show that the sheep price system was supply driven.(Emam, 1999) studied market price integration for livestock in Darfur region, she concluded that markets were integrated in case of cattle and sheep. She concluded that, supply side was leader in price formation. Moreover, (El Agip, 2001) examined cointegration and causality in five livestock markets (Omdurman, Medani, Elobied, Sennar and Nyala towns) using monthly nominal prices from January 1990 through December 1999. He found that spatial market cointegration was present between these cattle and sheep markets and the leading price discovery location was Elobied, in other words the system was supply driven. Also Bushara and Abdelmahmod reached the same results(M. Bushara & Abdelmahmod, 2015).

References

Akaike, Hirotugu. (1981). Likelihood of a model and information criteria. *Journal of econometrics, 16*(1), 3-14.

Akaike, Hirotugu. (1987). Factor analysis and AIC. *Psychometrika, 52*(3), 317-332.

Babiker, N. M. (2006). Livestock Markets in the Sudan:A Cointegration Approch; PhD. Thesis,University of Gezira

Babiker, N.M. , & Bushara, M. O.A. (2006). The spatial integration of sheep markets in the Sudan: A bivariate approach. *Gezira Journal of Agricultural Science (Sudan), 4*(2), 147-156.

Babiker, N.M. , & Bushara, M.O.A. (2006). Integration between cattle markets in the Sudan, 1980-2000. *Gezira Journal of Agricultural Science (Sudan), 4*(2), 130-146.

Bank, World. (2003a). Sudan Stabilization and Reconstruction: .

Bank, World. (2003b). World Development Report, 2003: World Bank. Washington, 2003, . 148–161.

Bushara, M.O.A. and Abdelmahmod, MKA. (2015). Efficiency of Selected Sudanese Cattle Markets: Multivariate Co-integration Approach (1995-2011). *International Journal of Economics & Management Sciences, 2015*.

Bushara, MOA, & Abdelmahmod, MKA. (2015). Efficiency of Selected Sudanese Cattle Markets: Multivariate Co-integration Approach (1995-2011). *International Journal of Economics & Management Sciences, 2015*.

Corporation, ARS. (2010). Livestock Market Statistical Data report 2010. Omdurman.

Crowder, William J. (2003). Panel estimates of the Fisher effect. *manuscript, University of Texas at Arlington*.

Davidson, Russell, & MacKinnon, James G. (1993). Estimation and inference in econometrics. *OUP Catalogue*.

Dickey, David A, & Fuller, Wayne A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association, 74*(366a), 427-431.

Dickey, David A, & Fuller, Wayne A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica: Journal of the Econometric Society*, 1057-1072.

El Agip, F. M. . (2001). Marketing of Livestock in the Sudan: An Analysis of its Efficiency.Unpublished Ph.D. Thesis: University of Khartoum, Sudan. .

Emam, A. A. (1999). Market Integration and its Impact on Food Security: A Case Study Selected Markets From Darfur. Unpublished Ph.D. Thesis, University of Khartoum, Sudan.

Engle, Robert F, & Granger, Clive WJ. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, 251-276.

Fisher, Irving. (1932). Booms and depressions.

Fund, I.M. (2006,). Sudan: 2006 Article IV Consultation and Staff-Monitored Programme Staff Report; IMF Country Report No. 06/182,Washington, DC: IMF, May 2006. .

Gonzalo, Jesus. (1994). Five alternative methods of estimating long-run equilibrium relationships. *Journal of econometrics, 60*(1), 203-233.

Goodwin, Barry K, & Schroeder, Ted C. (1991). Cointegration tests and spatial price linkages in regional cattle markets. *American Journal of Agricultural Economics, 73*(2), 452-464.

Gujarati, D. N. . (1995). "Basic Econometrics.3rd ed.Singapore.".

Hannan, Edward J, & Quinn, Barry G. (1979). The determination of the order of an autoregression. *Journal of the Royal Statistical Society. Series B (Methodological)*, 190-195.

Idris, B. . (2008). Livestock Marketing in Eastern and Central Sudan: Sector Policy Note, Sudan Multi Donor Trust Fund National. .

Idris, B. & Abdalla, A M. (2009). Spatial price transmission: A study of sheep markets in Sudan. *African Journal of Agricultural and Resource Economics, 3*(1), 43-56.

Johansen, Søren. (1988). Statistical analysis of cointegration vectors. *Journal of economic dynamics and control, 12*(2), 231-254.

Johansen, Søren. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica: Journal of the Econometric Society*, 1551-1580.

Levin, Andrew, Lin, Chien-Fu, & Chu, Chia-Shang James. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of econometrics, 108*(1), 1-24.

Phillips, Peter CB, & Perron, Pierre. (1988). Testing for a unit root in time series regression. *Biometrika, 75*(2), 335-346.

Rapsomanikis, Georege, Hallam, David, & Conforti, Piero. (2006). Market integration and price transmission in selected food and cash crop markets of developing countries: review and applications. *SARRIS, A. AND D. HALLAM: Agricultural Commodity Markets and Trade, Edward Elgar, Cheltenham, UK*, 187-217.

Sakr, IH, & Abdel Majid, AM. (1998). The Socio-Economics of Camel Herders in Eastern Sudan. The Camel Applied Research and Development Network: CARDN/ACSAD/CAMEL.

Schwarz, Gideon. (1978). Estimating the dimension of a model. *The annals of statistics, 6*(2), 461-464.

Sexton, Richard J, Kling, Catherine L, & Carman, Hoy F. (1991). Market integration, efficiency of arbitrage, and imperfect competition: methodology and application to US celery. *American Journal of Agricultural Economics, 73*(3), 568-580.

Startz, Richard. (2009). *Eviews illustrated for version 7*: Quantitative Micro Software.

Statistics, SudanCentral Burearu of. (2009). statistical surveillance (1991-2009), Sudan

Central Bureau of Statistics. (2008). Fifth census 2008, Sudan.

Sudan, Bank of. (2010). Annual reports (2005, 2006, 2007, 2008, 2009 and 2010). .

Wooldridge, Jeffrey M. . (2002). Econometric Analysis of Cross Section and Panel Data, Cambridge, MA: The MIT Press.