Efficiency of selected camel markets in Sudan: A multivariate approach (1995-2011)

Mohammed O. A. Bushara and Murtada Kh. A. Abdelmahmod

Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia

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

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.

Abstract

Despite the significant importance of camels to Sudanese economy but their markets still not well developed. The main constraints include poor market infrastructure, lack of market organization, inadequacy of market finance 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 production.

The main objective of this study is to investigate price movements among important camel markets in Sudan to explore their performance and pricing efficiency. The study focused on scrutinizing the Camel markets in Sudan by considering the prices of five livestock markets which were Elobied, Omdurman, Sennar and Nyala. The study covered the periods from January 1995 to December 2011.

The results showed that Omdurman camel market transforms the signal of prices toward other markets in the long run concluded that these markets were cointegrated, and the system was centered on Omdurman which mean the market was demand driven in the long run.

Policies may draw attention to turn consumer behavior towards camel meat consumption. Clear strategy may be developed to improve the camel meat industry and exporting activities through developing the slaughterhouse and freezing, cooling storage, transportation and insures the health services in national capital.

Key words: Market efficiency, cointegration, causality, camels and Sudan

1.1: Background:

The global economy witnessed a number of economic and financial crises since the late of 19th and early of 20th century, which caused a decline in consumption and private sector investment, rise in unemployment rate and slowdown in economic growth rates.

The global financial crisis of 2008, discerned with banking crisis, instability of foreign exchange and imbalances in stock markets. As the result of linkage between the international financial markets, their adverse effects outreached the performance of the international financial markets and the real sector through the slackening demand for goods and services. This engendered a decline in their prices, including oil prices during the last quarter of 2008(Sudan, 2010).

The international financial crisis affected the Sudanese economy indirectly, particularly during the first half of 2009 because of the decline in world oil prices, as the growth rate of the Sudan economy dropped from 7.8% in 2008 to 5.9%% in 2009 to 5.2%in 2010 to 2.7% in 2011. (Bank of Sudan 2009, 2010, 2011)(Sudan, 2012).That was in addition to the increase in the prices of most consumer goods which induced a rise in the inflation rate from 11.2% on average in 2009 to 13%in 2010 to 18.1% in 2011. However, Sudan was adversely affected by the global crisis through a decline in oil and other external receipts, political and economic uncertainty surrounding the South's self-determination added to the challenges faced by the economy.(Bushara, 2015)

Sudan after the secession dropped from a largest Africa's country to the second order after Algeria, and ranked to the third order as Arab world after Algeria and Saudi Arabia, it's also became the sixteenth largest country in the world. Sudan has lost 25% of its area where it was 2.5 million km^2 before secession and is now only 1.88 million km^2, It also has lost borders with three countries, and has a border with only 7 countries instead of 9 before the separation. The Sudanese Ministry of Information revealed that Sudan lies mostly between latitudes 8.45° N until latitudes 23.8 ° N, and longitudes 21.49° E until longitudes 38.34° E. The neighboring countries to the Republic of Sudan after the separation are: Eritrea, Ethiopia, Southern Sudan, Central Africa, Chad, Libya, and Egypt.

After the separation in July 2011 Sudan lost 90% of export revenue and 40% of public revenue which lead to adverse effects on economic activity in which represented in falling of real GDP growth rate from 1.9% in 2011 to 1.1% in 2012.

However, Sudan will need to boost non-oil growth and find alternative sources of foreign exchange receipts. To limit such risks, Sudan will need to address the challenges of improving governance, increasing access to basic services, and promoting pro-poor growth to ensure equitable development.

The Government plan toward agricultural development is to invest a part of oil revenues for the activation of agricultural sectors and to boost production to achieve the aspirations and economic goals, especially the creation of the economic boom in exports of non-petroleum resources like agriculture and livestock (ARSC)(Corporation, 2010).Unfortunately, slight progress in performance of the agricultural sector, relatively attributed to the implementing some of the development programs and the downturn in the animal resources section. In the additional; (1) reasons of this section drop is obvious the agriculture sector shares are still little and humble revenues with unstable shift, and (2) the overall state for all items of exports of non-petroleum products didn't attain the desired share of the export revenue or promote the state of the trade balance which has recently become out of deficit circle at the beginning of the year 2007 as shown in table (1.1):

Table 1: The Trade Balance (U.S.A Million Dollar) during the period (2005-2010)

period	Petroleum export	Non- Petroleum export	Total export	Total import	Trade balance
2005	4187.360	636.918	4824.278	6756.820	(1932.542)
2006	5087.211	569.357	5656.568	8073.498	(2416.930)
2007	8418.258	460.722	8879.250	8775.457	**1027.93**
2008	11094.111	576.393	11670.502	9351.540	**2318.964**
2009	7131.255	702.441	7833.696	9690.918	(1857.222)
2010	9905.248	1377.351	11282.779	8839.400	**2456.000**

Source: Bank of Sudan, annual reports (2005, 2006, 2007, 2008, 2009 and 2010)(Sudan, 2010)

The Table (1) above indicates high surplus with value of 2.456 Billion US$ in 2010 compared with surplus in 2008, 2007 with value 2.319, 1.1 pillion US$ respectively.

In the last decade the government has sought to increase exports of livestock and livestock products. Sudan's livestock exports fell dramatically in 2000-2001, however, when Saudi Arabia and other Gulf countries temporarily banned imports of live animals from Sudan (Bank, 2003b)and(Corporation, 2004). Since 2002 Sudan's livestock exports have rebounded, but they constitute a smaller part of non-oil exports than during the 1990s (Bank, 2003a). In 2005, oil accounted for 82 percent of Sudan's total exports by value; livestock and livestock products were just 3.2 percent of exports by value (or nearly 18 percent by value of non-oil exports),(Sudan, 2010).

In 2003 President Al-Bashir issued a set of directives to spur livestock exports, putting the Ministry of Foreign Trade in charge of re-organizing and improving Sudan's livestock markets. In November 2003 the Ministry directed the creation of a pilot Cattle Auction Project at El Muwelih market in Omdurman (Fahey & Leonard, 2007). This project would require payment in cash at the time of transaction and sale by weight and open auction, theoretically improving the overall efficiency and transparency of the marketing system (ARSC, 2004). If the project succeeds at El Muwelih it would be replicated at other livestock markets, but for now, the auction project is stalled owing to problems in organizing financial services to facilitate cash payments (Fahey & Leonard, 2007).

The implications of improved market facilities, open auctions, and increased exports for poor livestock owners have been inadequately studied. Overall the changes in the livestock marketing system appear designed to give the Government increased control over markets and transactions. More exports mean more revenue for the Government, but it is not clear that this will actually lead to higher prices and livelihood security for primary producers. In addition, the control of the marketing system by a few firms adversely affects poor livestock producers. Pro-poor initiatives could include legislation to break the monopoly of the few trading firms currently controlling the domestic and export markets.

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.

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, 4.623 million camels, 52 million sheep and 43 million goats as presented in Table(2)below:

Table2: 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: Central Bureau of Statistic, statistical surveillance 1991-2009(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; 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, 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 (Bank of Sudan 1999, 2001, 2005). 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 (Bank of Sudan 2005). 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" (IMF, 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 (Idris, 2003) 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 Babiker,(N. M. Babiker, 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, 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 international financial crisis affected the Sudanese economy indirectly as the growth rate dropped from 7.8% in 2008 to 5.9% % in 2009 to 5.2% in 2010 to 2.7% in 2011, rise in the

inflation rate from 11.2% in 2009 to 13% in 2010 to 18.1% in 2011.After the Sudan'ssecession, Sudan lost 90% of export revenue and 40% of public revenue which lead to adverse effects on economic activity in which represented in falling of real GDP from 1.9% in 2011 to 1.1% in 2012, added to the challenges faced by the economy. However, Sudan will need to address the challenges and to bolster non-oil growth and find alternative sources of foreign exchange receipts.

Despite the significant importance of livestock to Sudanese economy but its markets still not well developed. 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. So the results miss the comprehensiveness to livestock markets in Sudan.

This research 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.

1.3: The questions of the study:

To achieve the objectives of this study, the following questions need to be answered

1- Are the market prices of camel's data in the Sudan have stationarity properties over time?
2- Are the camel markets integrated?
3- Is camel price shock that happens in one market affecting the other markets?
4- Is there any price integration between these markets in the short and long run?

1.4: The objectives of study:

The main objective of this study is to investigate price movements among important livestock markets in Sudan to explore their performance and pricing efficiency.

From the mentioned research problem the following sub-objectives are distinguished:

1- To investigate camel market integration through analyzing price variation in selected markets.

2- To clarify the camel price efficiency.

3- To outline some policy recommendations, that might help policy makers to draw plans to improve the camel marketing system.

2: Data and Methodology:

The study focused on scrutinizing the camel markets in Sudan by considering the prices of five livestock markets which were Elobied, Omdurman, Sennar and Nyala. The study covered the periods from January 1995 to December 2011. The data used in these prices were monthly prices which have been collected from the animal resources company, these prices were wholesale prices i.e. the selling price of a head of animal measure in Sudanese Pound (S.P). To attain the cointegration analysis the data should be in real terms to avoid spurious regression, so all price series were deflated by GDP deflator rather than consumer price index. The deflated prices data were transformed in term of natural logarithm so as to attain a constant variance in the series, and then this logged deflated prices data used in the empirical analysis (Figures, 1.2 and 3).

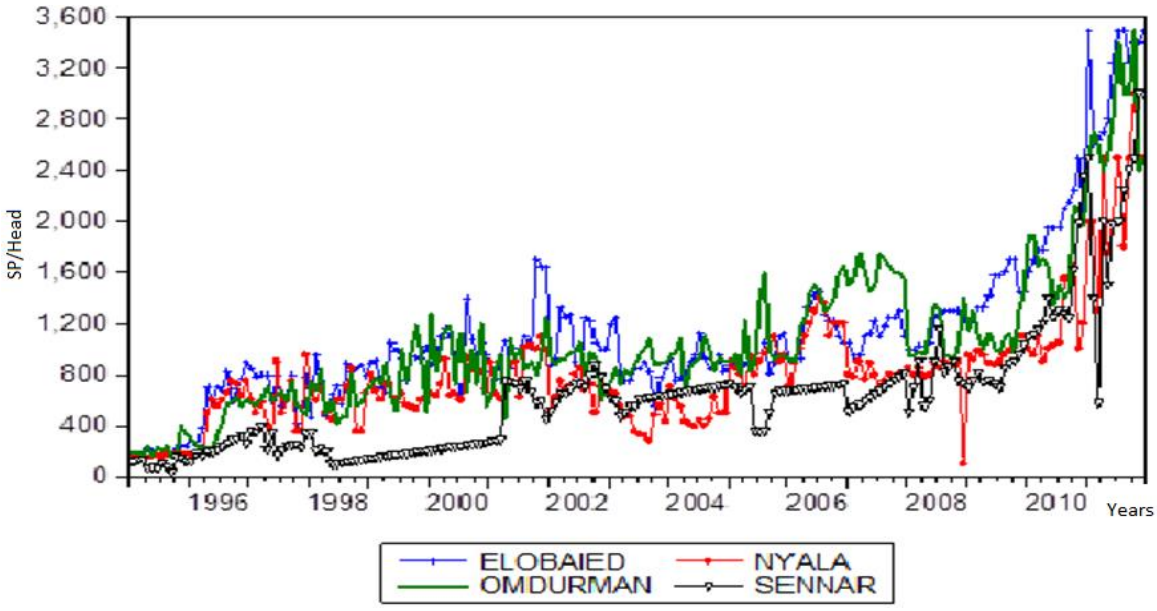


Figure 1: Monthly nominal wholesale price (Sudanese pound per head) of camels in the selected markets, January 1995- December 2011

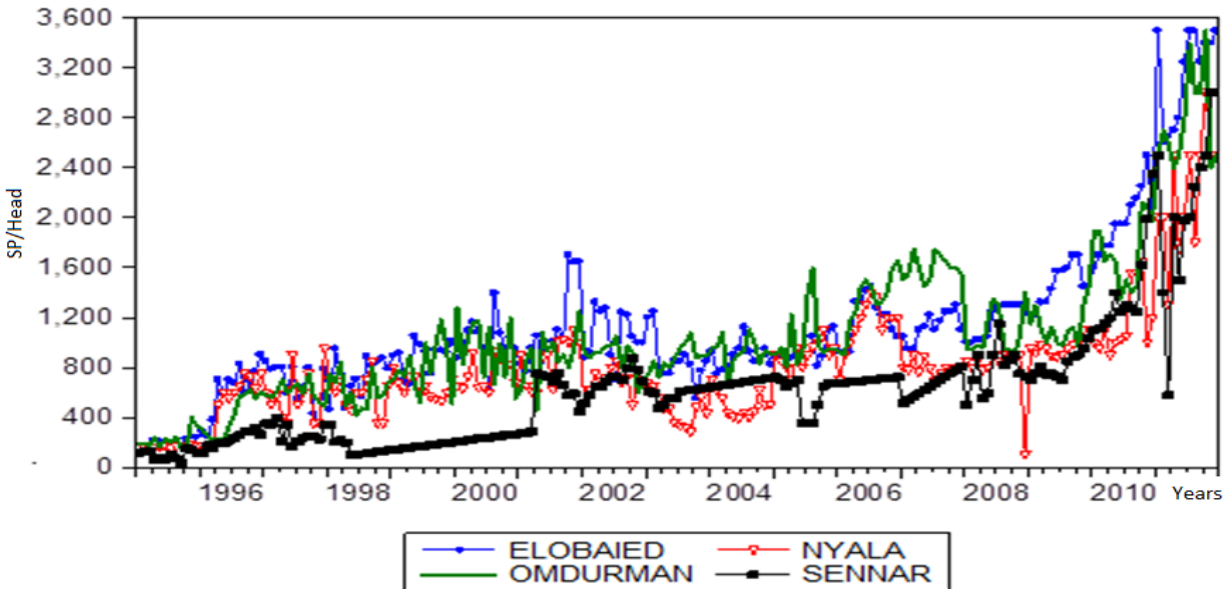


Figure 2: Monthly deflated wholesale price (Sudanese pound per head) of camels in the selected markets, January 1995- December 2011

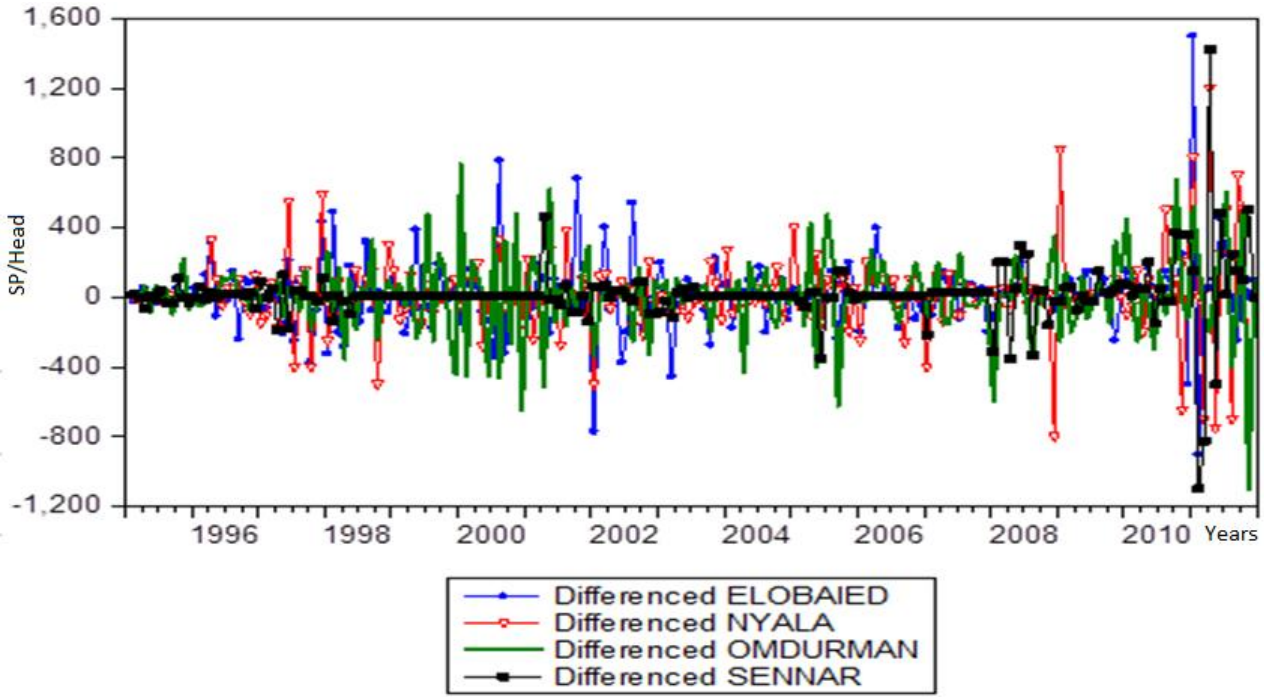


Figure 3: first difference of monthly deflated wholesale price (Sudanese pound per head) of camels in the selected markets, January 1995- December 2011

Testing for cointegration at the first step requires testing the order of stationarity of the variables. Integration tests or unit root tests are a prerequisite for cointegration tests, thus, an

econometric model cannot be specified unless its order of integration of the variables is known. The order of integration in the time series checked by the Augmented Dickey-Fuller(Dickey & Fuller, 1981) (ADF) and Phillips, P.C. and P. Perron(Phillips & Perron, 1988) tests, which are the most widely used methods for unit root tests. According to Babiker(N. B. Babiker, M. , 2006), in testing cointegration two conditions must be fulfilled: first the data series must have similar statistical properties, in particular, they must be integrated of the same order, 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.

2.1Johansen Maximum Likelihood Ratio Approach:

Johansen's methodology takes its starting point in the vector auto regression (VAR) of order *p* given by:

$$Y_t = \mu + A_1 y_{t-1} + \dots + A_p y_{t-p} + \varepsilon_t \quad \dots\dots (1)$$

Where $y_t$is a *k*-dimension vector of variables which are assumed to be I(1) series (but could also be I(0)), A_i, $i = 1, \dots p$ is the coefficient matrix, and $\varepsilon_t$is a *k*-dimension vector of residuals. Subtracting y_{t-1} from both sides of equation (1) yields:

$$\Delta y_t = \mu + \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \cdots + \Gamma_{p-1} \Delta y_{t-p+1} + \varepsilon_t \quad \dots\dots (2)$$

This VAR can be re-written as:

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \quad \dots\dots (3)$$

Where $$\Pi = \sum_{i=1}^{p} A_i - 1 \quad \dots\dots (4)$$

And $$\Gamma_i = \sum_{j=i+1}^{p} A_j \quad \dots\dots (5)$$

From equation (3) the only one term in the equation, Πy_{t-1}, is in levels, cointegration relations depend crucially on the property of matrix Π. It is clear that Πy_{t-1} must be either *I*(0) or zero except that $y_t$is already stationary. There are three situations:

(a) $\Pi = \boldsymbol{\alpha\beta'}$ has a reduced rank $0 < r < k$,

(b) $\Pi = \boldsymbol{\alpha\beta'}$ has a rank of zero, and

(c) $\Pi = \boldsymbol{\alpha\beta'}$ has a full rank.

Under situation (a), $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are both $k \times r$ matrices and have a rank of r. There are r cointegration vectors $\boldsymbol{\beta}'\mathbf{y}_t$ which are stationary $I(0)$ series. It is equivalent to having r common trends among $\mathbf{y}_t$. The stationarity of $\boldsymbol{\beta}'\mathbf{y}_t$ implies a long-run relationship among $\mathbf{y}_t$or a sub-set of $\mathbf{y}_t$, the variables in the cointegration vectors will not depart from each other over time. $\boldsymbol{\beta}'\mathbf{y}_t$ are also error correction terms in that departure of individual variables in the cointegration vectors from the equilibrium will be subsequently reversed back to the equilibrium, a dynamic adjustment process called error correction mechanism (ECM). Equation (3) is therefore called VAR with ECM. Under situation (b), there is no cointegration relation among $\mathbf{y}_t$ and the variables in levels do not enter equation (3), and then equation (3) becomes a simple VAR without ECM. The variables in levels are already stationary under situation (c).

Johansen proposes two different likelihood ratio tests of the significance of these canonical correlations and thereby the reduced rank of the $\boldsymbol{\Pi}$ matrix: the trace test and maximum eigenvalue test, shown in equations (6) and (7) respectively.

a-The Trace Statistic Test:

The trace statistic test the null hypothesis of r cointegrating relations against the alternative of k cointegrating relations, where k is the number of endogenous variables, for r = 0, 1, ..., k - 1. The alternative of k cointegrating relations corresponds to the case where none of the series has a unit root and a stationary VAR may be specified in terms of the levels of all of the series. The trace statistic for the null hypothesis of r cointegrating relations is computed as:

$$\pi_{\text{trace}}(r|k) = -T \sum_{i=r+1}^{n} \boldsymbol{ln}\,(1 - \hat{\lambda}_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Where λ_i is the i-th largest eigenvalue of the matrix in (4) and (5).

b - The maximum Eigenvalue Statistic Test:

The second test is maximum eigenvalue statistic which tests the null hypothesis of (r) cointegrating relations against the alternative of (1+r) cointegrating relations. This test statistic is computed as:

$\pi_{max}(r|\ r + 1) = -T\ \ln(1 - \hat{\lambda}_{r+1})$ ……………………..…………………...……..……(7)

Neither of these test statistics follows a chi square distribution in general; asymptotic critical values could be found in,(Soren Johansen & Juselius, 1990) and are also given by most econometric software packages. Since the critical values used for the maximum eigenvalue and trace test statistics are based on a pure unit-root assumption, they would no longer be corrected when the variables in the system are near- unit-root processes. By default, E-views program reports the value based on,(Davidson & MacKinnon, 1993)*p*-values for Johansen's cointegration trace test and maximum eigenvalue test.

3: Results and Discussion of the Multivariate Cointegration Approach for Camel:

This section presents the results of vector autoregression (VAR) of(Søren Johansen, 1988, 1991) which the joint effect of prices in all markets in concern were accounted for.In this section a multivariate cointegration analysis was conducted using the vector autoregressive (VAR) model of Johansen, which is based on the estimation of maximum likelihood (Soren Johansen & Juselius, 1990)using E-Views software program(Startz, 2009).

3.1: The Order of Vector Autoregressive Model:

The lag structure of the estimated VAR was examined using a combination of VAR lag order selection information criteria (Akaike (AIC)(Akaike, 1981), Schwarz Bayesian (SBC), likelihood ratio (LR) (Schwarz, 1978)and Quinn (HQ) information criterion) (Hannan & Quinn, 1979)and checking that the inverse roots of the characteristic polynomial lie within a unit circle, which is a condition for having a stable VAR system. This process led to the choice of three lags according to Final Prediction Error (FPE), Akaike information criterion (AIC) and likelihood ratio (LR), which was used in cointegration test and subsequent analyses. Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) suggested three lags as shown in Table (3).

Table (3) Vector Autoregressive (VAR) Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-225.5266	NA	0.000122	2.342109	2.409009	2.369193
1	94.47779	623.6821	5.50e-06	-0.759977	**-0.425476***	**-0.624555***
2	112.6289	34.63528	5.38e-06	-0.781928	-0.179825	-0.538168
3	130.1213	**32.66429***	**5.30e-06***	**-0.797156***	0.072548	-0.445058
4	142.1392	21.95118	5.52e-06	-0.756523	0.380782	-0.296087
5	156.5044	25.65218	5.63e-06	-0.739841	0.665065	-0.171068
6	170.1535	23.81623	5.78e-06	-0.715852	0.956655	-0.038741
7	184.3230	24.14596	5.90e-06	-0.697173	1.242935	0.088276
8	199.8166	25.76991	5.96e-06	-0.692006	1.515704	0.201781

* indicates lag order selected by the criterion
LR: LR test statistic (each test at 5% level)
FPE: Final prediction error,
AIC: Akaike criterion
SC: Schwarz criterion
HQ: Hannan-Quinn criterion

Examination of the inverse roots of the AR characteristic within the unit circle for the VAR specification indicated that no root lies outside the unit circle and the VAR satisfies the stability condition under using three lags, i.e. if the estimated VAR process is (covariance) stationary, then all AR roots should lie inside the unit circle as showing in table (8.11) and figure(4) below.Table (4) below shows that all AR roots were less than one and counted positive and negative (invers) values. These values lie inside the unit circle as showing in figure (4)below indicating that the VAR satisfies the stability condition.

Table (4):Roots of Characteristic Polynomial

Root	Modulus
0.914748	0.914748
0.897387	0.897387
0.619286	0.619286
0.541923	0.541923
-0.296598	0.301102
-0.296598	0.301102
-0.204843	0.204843
0.019304	0.019304

No root lies outside the unit circle.

VAR satisfies the stability condition.

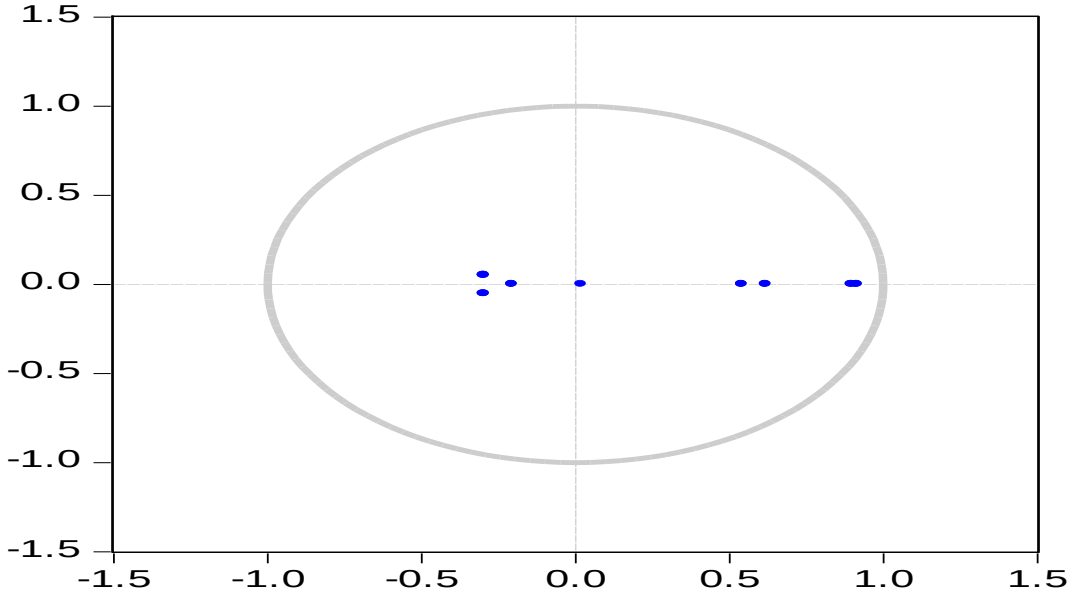


Figure (4) Inverse Roots of AR Characteristic Polynomial

- The horizontal axis is the real part of root.
- The vertical axis is the imaginary part of root.

The roots test display the inverse roots of the VAR characteristic polynomial. The roots may be displayed as a graph or as a table. The graph view plots the roots in the complex plane where the horizontal axis is the real part and the vertical axis is the imaginary part of each root. The table displays all roots in order of decreasing modulus (square root of the sum of squares of the real and imaginary parts).

3.2: Number of cointegration vectors for camel prices:

The result of the previous stage was used to determine the cointegrating vectors in the models on the maximum eigenvalue, the trace of the stochastic matrix test of Johansen (1988 and 1991) and the three model selection criteria i.e. HQC, SBC and AIC were also used.

Table(5): Johansen Tests Results for Number of Cointegrating Vector, camel Prices 1995M1-2011M12

The Trace Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.130484	55.41393	47.85613	0.0083
At most 1	0.094470	27.45018	29.79707	0.0911
At most 2	0.021961	7.603157	15.49471	0.5088
At most 3	0.015686	3.162092	3.841466	0.0754

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999)(MacKinnon, Haug, & Michelis, 1999) p-values

The Maximum Eigenvalue Test

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.130484	27.96375	27.58434	0.0447
At most 1	0.094470	19.84702	21.13162	0.0748
At most 2	0.021961	4.441066	14.26460	0.8101
At most 3	0.015686	3.162092	3.841466	0.0754

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

Table (5)above displays the result of Johansen likelihood ratio test. In this table the null hypothesis of no cointegration (r=0) among variables was rejected in both trace test statistic and the maximum eigenvalue statistic, under this hypothesis (r=0) the trace of stochastic matrix was (55.41393) and the maximum eigenvalue statistic was (27.96375), these were above their corresponding 95% critical values of (47.85613) and (27.58434) respectively. Moreover, a hypothesis of numbers of cointegration vector in trace test in two forms (r=1) and (r=2) were accepted at 5% significant level. Therefore, the trace of stochastic matrix and maximum eigenvalue test indicated one cointegrating equations at the 0.05 significant levels.

3.3: Estimation of Vector Autoregressive (VAR) Model for Camel Prices:

In this study, stationary variables of prices series were tested using Augmented Dickey Fuller (ADF) and Phillips-Perron unit root test in level and first differences. The lag structure of the estimated vector autoregressive (VAR) model was examined using a combination of VAR lag order selection information criteria which were determined three lag length as indicated in table (8.10) above. The result of the VAR model presented in Table (6) below, each column in the table corresponds to an equation in the VAR model. The bold figures inside the table explained the significant coefficient. For example, the coefficient for Elobied (-1) in Omdurman equation is (0.191837) which was significant at 5% level. The results are computed separately for each equation using the appropriate residuals and are displayed in

the corresponding column. The numbers at the very bottom of the table are the summary statistics for the VAR system as R-squared, F-statistic, Log likelihood, Akaike information criterion and Schwarz criterion.

To examine the results presented in Table (6)below the results are highly significant according to the standard *F* test for each model. The goodness of fit (R^2) was high in all models.

Table (6): Vector Autoregression (VAR) Estimates for camel prices

	ELOBIED	NYALA	OMDURMAN	SENNAR
ELOBIED(-1)	**0.513404** [6.29805]	0.135319 [1.38288]	**0.191837** [2.20986]	**0.206002** [2.07604]
ELOBIED(-2)	0.007434 [0.08325]	-0.028943 [-0.26999]	-0.083127 [-0.87410]	-0.162221 [-1.49230]
ELOBIED(-3)	**0.270419** [3.32265]	0.118850 [1.21653]	0.103271 [1.19154]	0.134686 [1.35952]
NYALA(-1)	0.044645 [0.65012]	**0.570359** [6.91896]	0.070420 [0.96294]	**-0.175667** [-2.10148]
NYALA(-2)	0.141656 [1.77957]	0.027871 [0.29168]	0.050297 [0.59335]	0.104108 [1.07444]
NYALA(-3)	-0.041361 [-0.58458]	**0.186225** [2.19266]	0.009703 [0.12878]	-0.026038 [-0.30233]
OMDURMAN(-1)	0.032926 [0.47523]	-0.103366 [-1.24286]	**0.320310** [4.34133]	-0.000380 [-0.00451]
OMDURMAN(-2)	**-0.162256** [-2.27369]	-0.061601 [-0.71910]	0.140799 [1.85273]	-0.132151 [-1.52131]
OMDURMAN(-3)	0.083670 [1.27146]	0.086127 [1.09031]	0.028518 [0.40694]	0.059077 [0.73751]
SENNAR(-1)	**0.147388** [2.44788]	0.084289 [1.16621]	**0.199713** [3.11471]	**0.703574** [9.59964]
SENNAR(-2)	-0.046822 [-0.63606]	-0.063609 [-0.71984]	-0.155616 [-1.98510]	0.063243 [0.70579]
SENNAR(-3)	-0.077909 [-1.26783]	-0.037181 [-0.50404]	-0.045032 [-0.68813]	0.110525 [1.47756]
R-squared	0.756000	0.740019	0.630587	0.726471
F-statistic	48.54102	44.59415	26.74296	41.60938

Depending on *t*-statistic, the significant coefficient in the models presented in Table (8.13) can be presented as follows:

$\hat{\mathbf{E}}_t = 0.51\mathbf{E}_{t-1} + 0.27\,\mathbf{E}_{t-3} - 0.16\,\mathbf{O}_{t-2} + 0.15\,\mathbf{S}_{t-1}$ ……...……(8.1)

$\mathbf{R^2} = 76\%$, **F**-statistic = 48.5

$\hat{\mathbf{O}}_t = 0.19\mathbf{E}_{t-1} + 0.32\,\mathbf{O}_{t-1} + 0.19\,\mathbf{S}_{t-1}$ ……(8.2) $\mathbf{R^2} = 63\%$, **F**-statistic = 26.7

$\hat{\mathbf{S}}_t = 0.21\mathbf{E}_{t-1} - 0.18\,\mathbf{N}_{t-1} + 0.70\,\mathbf{S}_{t-1}$ ……(8.3) $\mathbf{R^2} = 73\%$, **F**-statistic = 41.6

$\hat{\mathbf{N}}_t = 0.57\mathbf{N}_{t-1} - 0.19\,\mathbf{N}_{t-3}$ ……(8.4)
$R^2 = 74\%$, F-statistic = 44.6

Where **E** standing for Elobied**, O** for Omdurman**, S** for Sennar and **N** standing for Nyala.

The first model shows that Elobied market was effected by its own price lagged one and three months, and also affected by Omdurman price lagged two months. An increase in the level of Omdurman price lagged two months leads to decrease in the level of prices in Elobied prices by 16%. This phenomenon has no clear justification but may due to traders' expectations. On the other hand an increase in the level of Sennar price lagged one month leads to increase in the level of Elobied prices.R^2 in this model suggested that 76% of variability in Elobied market caused by the variability in Elobied, Omdurman and Sennar prices during past periods.

According to the second equation of Omdurman equation, Elobied, Omdurman and Sennar lagged one month, were statistically significant which means that the camel prices of last month in Elobied, Omdurman and Sennar affected the prices of Omdurman in the current month by 19% and 20% respectively. The positive coefficient sings explain the positive relationship between Omdurman and Omdurman itself, Omdurman and Elobied and between Omdurman and Sennar market, which means an increase in the level of Elobied and Sennar price lagged one month leads to an increase in the level of Omdurman prices. Sennar market affected by Elobied and Sennar itself lagged one month. Nyala market prices affected on Sennar market prices inversely. Figure(5)bellow show lines connected camel markets whose prices are affecting on each other.

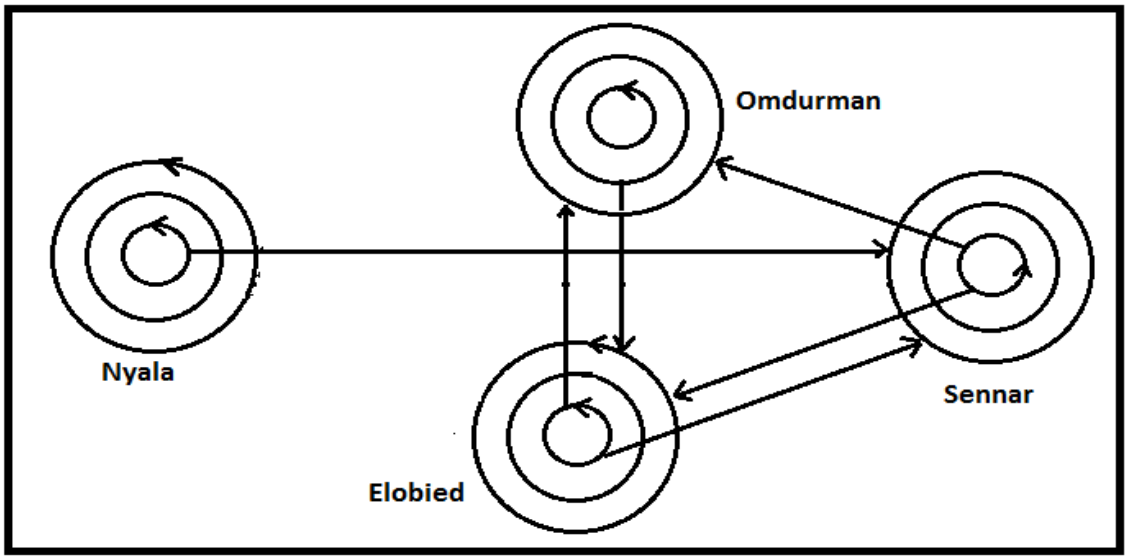


Figure (5): Lines connected camel markets whose prices were affected by each other 1995m1- 2011m12

The connection between Sennar and Nyala camel markets may be due to trader's relationship in these markets but the separation of Nyala market from others refer to exporting of camel to Egypt in sense that the Egyptian market is the main market for Sudanese camels.(Idris, 2003)(2003) stated that about 200,000 camels are exported (and smuggled) to Egypt annually(Idris, 2003).

3.4: Estimating Vector Error Correction (VECM) Models for Camel Prices:

After obtaining the order of vector autoregressive models, the Number of cointegration vectors and Estimation of vector autoregressive (VAR) model results, the next stage in the model building process requires the construction of a multivariate VECM for camel prices in Elobied, Omdurman, Nyala and Sennar where the time series were found to be cointegrated. Using information constructed from above results, one cointegration vector and three lag lengths were imposed in estimation of Vector Error Correction (VECM) Models, the long and short run matrices were extracted and presented below. These matrices describe the system dynamics.

3.4.1 : Cointegration Short Run Dynamics Matrices (Γ) for Camel Prices:

Table (7) presents the short run matrix for camel prices in selected markets. Again as the VAR table result, each column in the table corresponds to an equation in the VECM (short run dynamics). The variables in the table which preceded by capital letter (D) stand for the differences process.

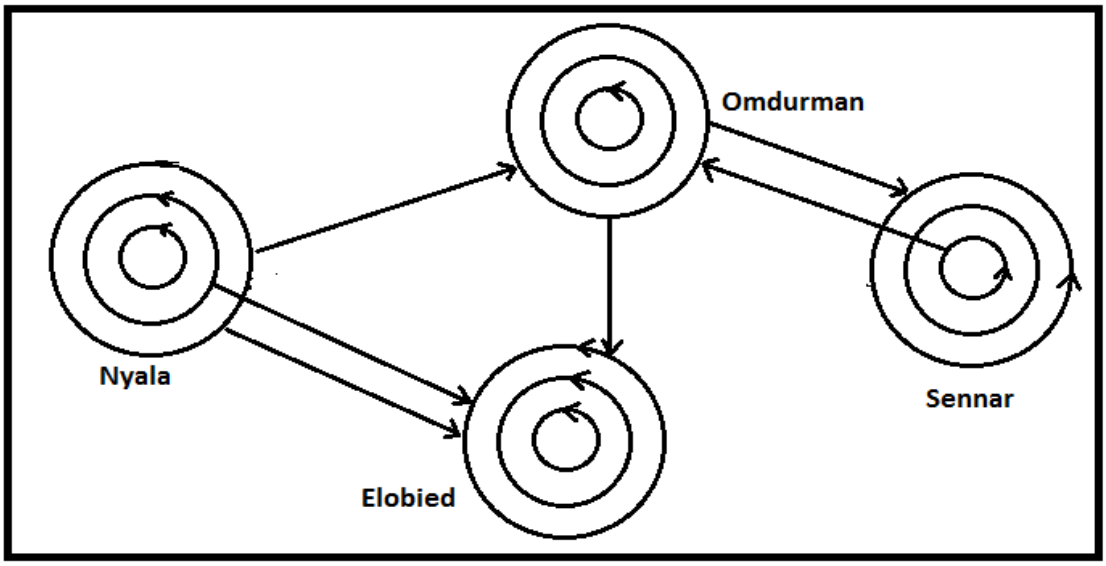
Table (7): Vector Error Correction Estimates {short run dynamics matrix (Γ) }for camel prices

Error Correction:	D(ELOBIED)	D(NYALA)	D(OMDURMA)	D(SENNAR)
D(ELOBIED(-1))	**-0.467586** [-4.91839]	-0.054116 [-0.45637]	-0.093251 [-0.91628]	0.102235 [0.88627]
D(ELOBIED(-2))	**-0.380364** [-4.21133]	-0.094883 [-0.84224]	-0.098575 [-1.01953]	-0.128303 [-1.17074]
D(ELOBIED(-3))	**-0.190275** [-2.34147]	-0.038859 [-0.38337]	0.028994 [0.33329]	0.015957 [0.16183]
D(NYALA(-1))	0.034892 [0.52637]	**-0.317986** [-3.84591]	0.109031 [1.53649]	-0.127408 [-1.58404]
D(NYALA(-2))	**0.145244** [2.18074]	**-0.249738** [-3.00618]	0.113133 [1.58675]	0.017562 [0.21732]
D(NYALA(-3))	**0.169921** [2.54063]	0.065739 [0.78803]	**0.167641** [2.34147]	0.016166 [0.19921]
D(OMDURMAN(-1))	0.009670 [0.11991]	-0.001280 [-0.01273]	**-0.260269** [-3.01479]	0.129759 [1.32605]
D(OMDURMAN(-2))	-0.153507 [-1.99383]	-0.068701 [-0.71540]	-0.110942 [-1.34607]	0.047074 [0.50390]
D(OMDURMAN(-3))	**-0.146985** [-2.28547]	-0.008692 [-0.10835]	-0.087442 [-1.27009]	**0.158977** [2.03723]
D(SENNAR(-1))	0.113297 [1.93434]	0.089512 [1.22524]	**0.211466** [3.37264]	**-0.256510** [-3.60930]
D(SENNAR(-2))	0.085997 [1.38455]	0.039790 [0.51360]	0.036616 [0.55070]	-0.196097 [-2.60195]
D(SENNAR(-3))	-0.067284 [-1.12583]	-0.052232 [-0.70069]	-0.072309 [-1.13024]	**-0.155722** [-2.14743]
R-squared	0.277895	0.183382	0.387792	0.164521
F-statistic	5.506176	3.212974	9.062955	2.817451

The goodness of fit (R^2) was weakly for all models but *F*- Statistic test was significant in four equations. Elobied camel prices were affected by its own prices and effected by Omdurman and Nyala markets in the short run.

Nyala market prices in second equation were affected just by its own prices while Omdurman affected Nyala lagged three months, and Omdurman lagged one affected Sennar lagged one month.

Sennar market shows three significant coefficients that were Omdurman lagged three months and Sennar itself lagged one and three. The linkages between markets in the short run are presented in Figure (6) below.



Figure(6): Lines connected camel markets whose prices were cointegrated in the short run, 1995m1- 2011m12

The above figure also gives information on the interaction of camel prices in markets with each other, it's clear that Elobied market is affected by other markets prices but it's not affecting on other markets, that may be due to its geographical location. The result that attract to attention is Nyala market which affect Omdurman and Elobied camel prices and it's not affected by others markets. This confirmed that Nyala camel market is the main source of exports.

4.3.2: Cointegration Long Run Equilibrium Matrices (Π)for camel prices:

The long run equilibrium matrices (Π) describe the long run effect. These matrices are extracted from the error correction models presented in Table (8) below:

Table (8): Cointegration long run equilibrium matrices (Π) for camel prices -1995m1-2011m12

	Elobied	Omdurman	Sennar	Nyala
D(Elobied)	-0.022353 [-0.35066]	0.026782 [0.35066]	0.002344 [0.35066]	0.003165 [0.35066]
D(Omdurman)	**0.327626** [4.80117]	**-0.392546** [-4.80117]	**-0.034355** [-4.80117]	**-0.046387** [-4.80117]
D(Sennar)	0.113427 [1.46648]	-0.135903 [-1.46648]	-0.011894 [-1.46648]	-0.016060 [-1.46648]
D(Nyala)	0.119592 [1.50412]	-0.143290 [-1.50412]	-0.012540 [-1.50412]	-0.016933 [-1.50412]

- The coefficients in bold font are significant at 0.05 significant levels.
- The figures in parentheses are the t-ratio for the estimates.
- D stand for the changes in the variables in concern.

From the above Table(8) the following equations could be constructed:

E = 0.327626 ΔO ..……..…….……...…….……..(8.5)

O = 0.019520 ΔO …….…….……..……..(8.6)

S = -0.034355 ΔO ……...…….…….…..……..(8.7)

N = -0.046387 ΔO ……..…….……..…..……..……..(8.8)

Where E standing for Elobied, O for Omdurman, S for Sennar, N for Nyala and Δ denoted the change in the variables. As evident in Table(8), the error correction terms is significant just in Omdurman market indicating that, the level of camel prices in Omdurman exert significant long run effect on the current development of prices of Elobied, Omdurman, Sennar and Nyala, suggesting the validity of the long run equilibrium relationship. But the levels of camel prices of Elobied, Sennar and Nyala markets have no significant long run effect on the prices of other markets as well. The result showed that Omdurman camel market transforms the signal of prices toward other markets in the long run concluded that Omdurman market was cointegrated with other markets, and the system was centered around Omdurman which

mean that market was demand driven in the long run. This result indicated that Omdurman camel market had a possibility to overcome and dominate camel marketing in the long run. The interpretation behind that is the changing of consumer behavior in national capital toward camel meat, the growing of camel meat industry and exporting through developing the slaughterhouse and abattoir services which compliance with health standards set internationally and prepared for freezing, cooling storage and transportation, insures the health services in national capital. On the other hand decreasing the Egyptian exporting dependency, controlling export process and looking for other international market especially Arab countries, all these explain the domination of Omdurman camel market in the feature. According to Idris (2006)(Idris, 2006) camel producers and traders want all of the Arab countries, especially the Gulf States to be a market for their products. There is validity to this, however most exporters are currently small producers. This makes Egypt the destination of choice. If the trade and marketing system could be developed with grades and standards introduced and implemented, together with other recommendations, perhaps exports would increase on the whole, transport fees by trucks to Port Sudan would drop and the situation would change. Figure (7) below presents these linkages between markets.

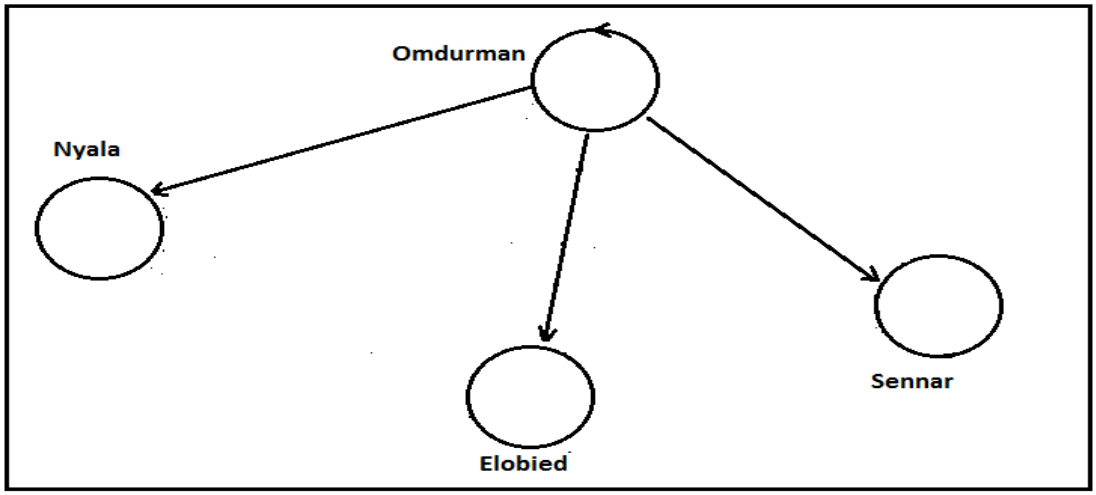


Figure (7): Lines connected camel markets whose prices were cointegrated in the long run, 1995m1- 2011m12

- Source: drawing using the long run equilibrium matrix (Π) Table (8).

4.3.3: Diagnostic tests:

In order to check data properties up, it needs to satisfy a range of diagnostic tests. The diagnostic tests usually include Lagrange multiplier test for autocorrelation, Ramsey's "RESET" test for functional form, Jarque-Bera for normality test and ARCH test for heteroscedasticity tests. The results of diagnostic tests of camel prices in Table (9) were robust as they satisfied almost all relevant diagnostic tests. But with the exception of Nyala, the model suffer just from normality problem as indicted in Jarque-Bera test p-value (0.17228), which failed to reject the null hypotheses of non-normal distribution.

Table (9): Diagnostic tests results for camel prices, (1995-2011).

Tests / Equation	Lagrange multiplier test	Ramsey's RESET	Jarque-Bera test	ARCH test
Elobied	15.76272 (0.0000)	4.356093 (0.0054)	0.12233 (0.00116)	4.363282 (0.0058)
Omdurman	20.82426 (0.0000)	21.69814 (0.0000)	7.41795 (0.02450)	22.97818 (0.0000)
Sennar	119.0833 (0.0000)	8.342329 (0.0000)	23.28580 (0.0000)	120.0098 (0.0000)
Nyala	33.14600 (0.0000)	4.207647 (0.0065)	3.51732 (0.17228)	19.43041 (0.0000)

The figures between brackets are the rejection probability.

One possible explanation for this problem is 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, (N. M. Babiker, 2006). 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.(Bushara, 2015)

3.3.4: Impulse Response Approach Results for camel prices:

An impulse-response analysis was also carried out to better understand dynamic price interrelationships, how price shocks are transmitted, and how long it takes for shocks to be eliminated in alternate markets. Figures (8.6, 8.7, 8.8 and 8.9,) below give response function to a price shock equal in size to one stander error in each market equation over a 36 months horizon.

Figure (8) below represents the impulse response in Omdurman, Sennar and Nyala markets due to one standard error price shock in Elobied market. It's obvious that all markets take nine month for the Elobied market to eliminate the price shock and converge onto long-run equilibrium. The long period of long-run equilibrium adjustment indicated that there are weak price linkages and information between Elobied and other camel markets individually.

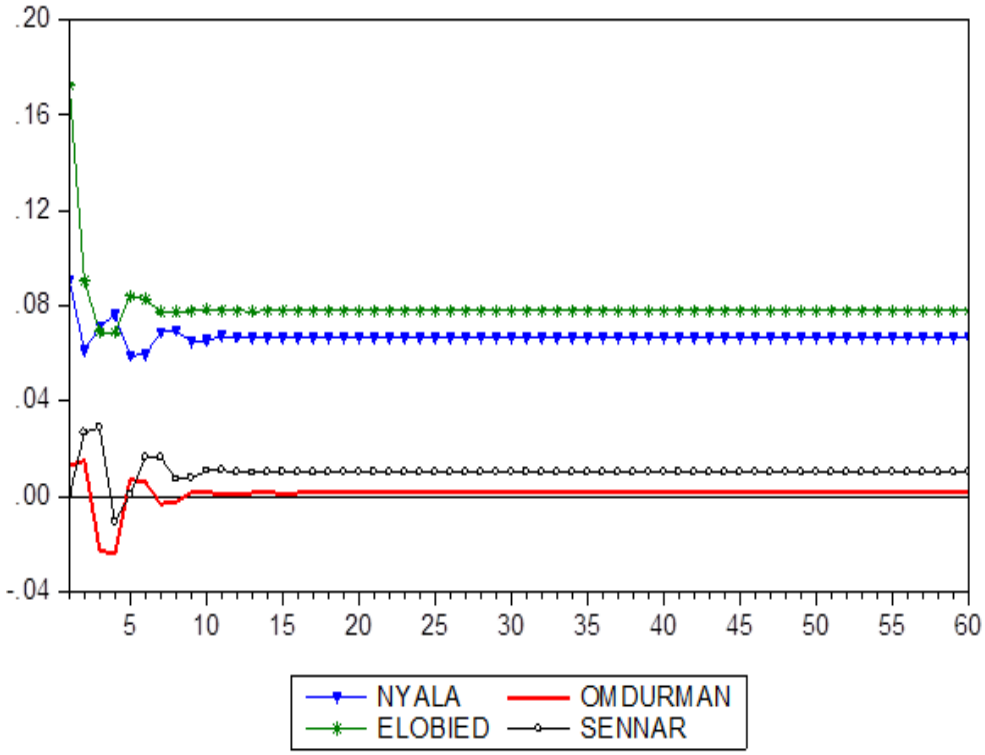


Figure (8): Generalized impulse response to one standard error shock in the equation of Elobied camel prices 1995m1-2011m12

- Y axis is stander error (SD).
- X axis is months.
- Source: Author calculation.

Figure (9)below illustrates Elobied, Sennar and Nyala markets, which in response to a shock in Omdurman markets. Elobied and Nyala markets adjusted within seven months while Sennar adjust within nine months and converge onto long-run equilibrium. The above indicated that Omdurman as consumption market had essential linkage with Kordofan and Darfur regions to receive camel supply.

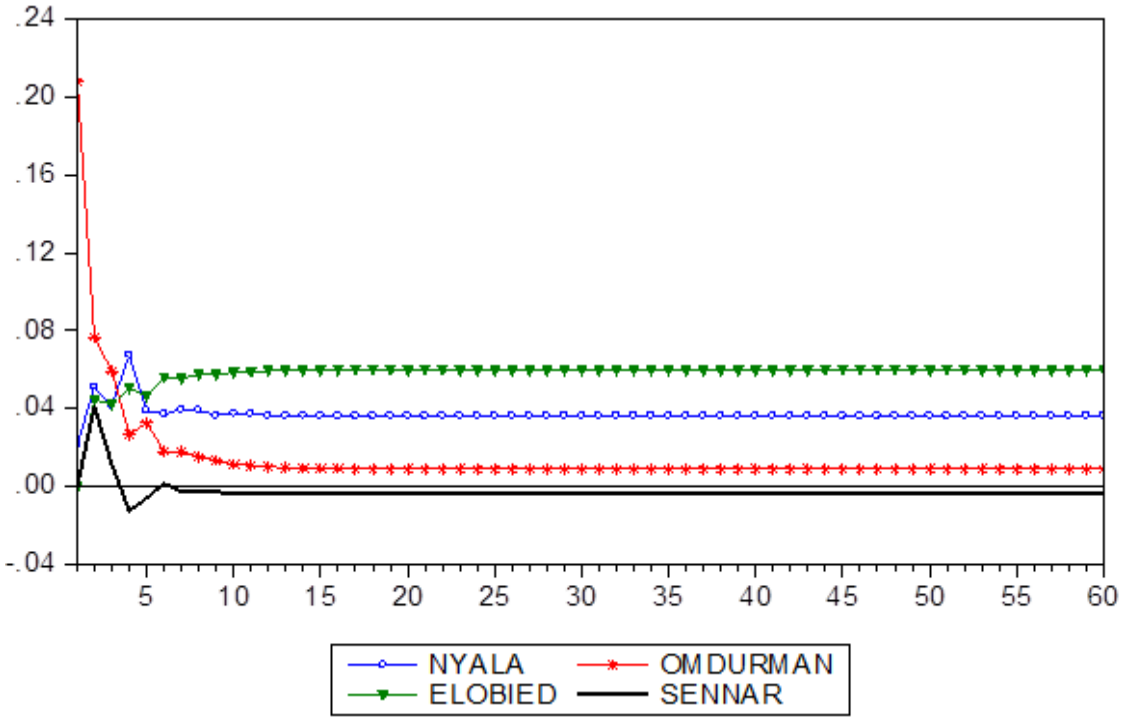


Figure (9): Generalized impulse response to one standard error shock in the equation of Omdurman camel prices 1995m1-2011m12

- Y axis is stander error (SD).
- X axis is months.

Figure (10) below explains a standard error shock in Sennar and its response in Elobied, Omdurman and Nyala. In response to a standard error shock in Sennar market, the figure mentioned that Elobied, Nyala and Omdurman markets adjusted within eight months to adjust the shock and converge onto long-run equilibrium. It was reasonable finding in case of Elobied and Nyala markets but Omdurman need less period to adjust because of availability of information between these two markets.

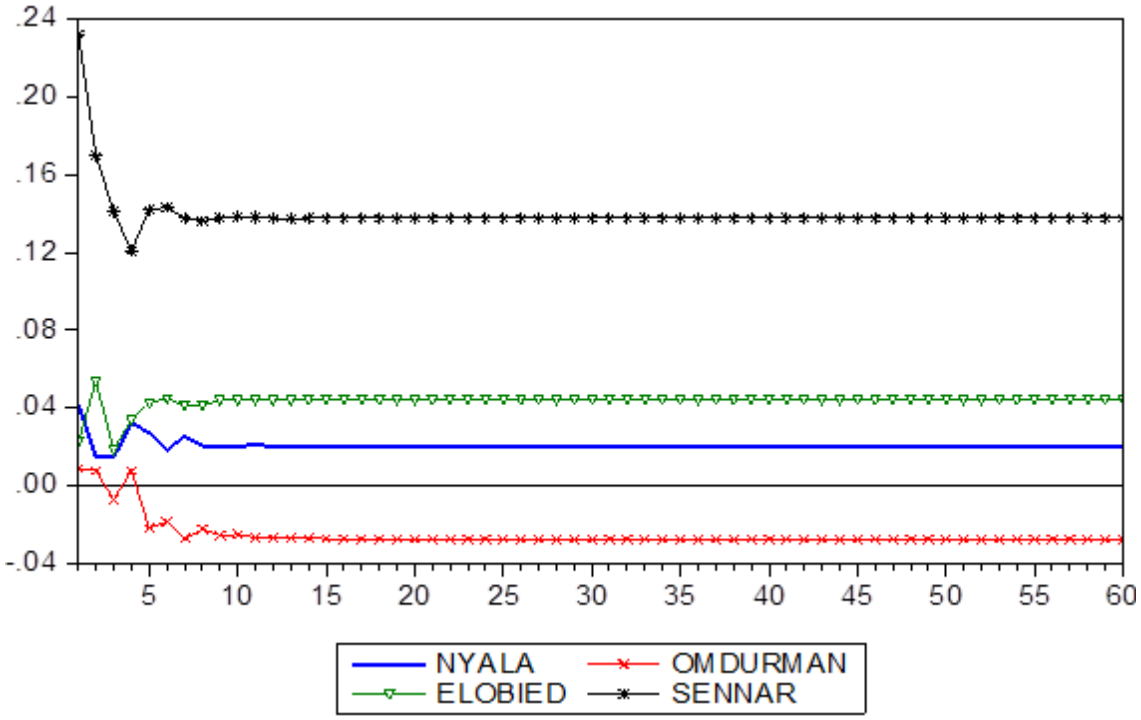


Figure (10): Generalized impulse response to one standard error shock in the equation of Sennar camel prices 1995m1-2011m12

- Y axis is stander error (SD).
- X axis is months.

Figure (11) below illustrated Elobied, Omdurman and Sennar markets, which in response to a shock in Nyala markets. Elobied market adjusted within seven months while Sennar and Omdurman markets adjust within eight months and converge onto long-run equilibrium. Also its reasonable according to the same nature of Elobied and Nyala markets as located in production areas while Sennar and Omdurman markets was far away from Nyala market.

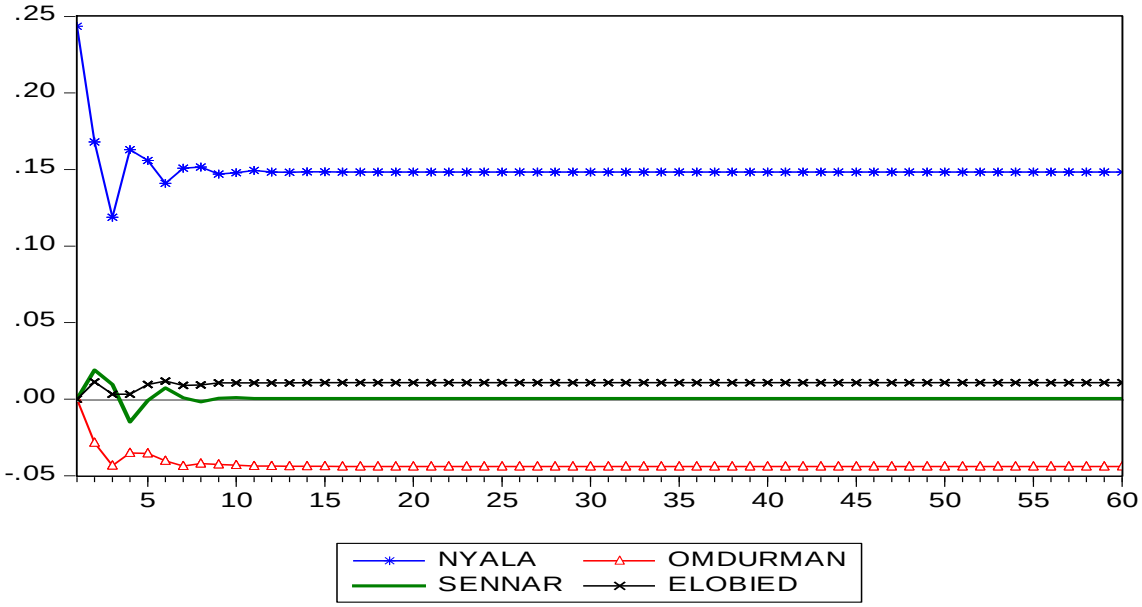


Figure (11): Generalized impulse response to one standard error shock in the equation of Nyala camel prices 1995m1-2011m12

- Y axis is stander error (SD).
- X axis is months.
-

3.3.5: Pairwise Granger Causality Analysis:

Granger causality is also estimated between pairs of domestic camel markets in Sudan during the period of study. Granger causality means the direction of price formation between two markets and related spatial arbitrage, i.e., physical movement of the commodity to adjust for these prices differences. Table (10) gives the results of the Granger causality test.

Table (10) below shows that, in Elobied, Omdurman Sennar and Nyala markets there were four relations exhibited directional causality, which were Sennar Granger cause Elobied while Elobied Granger cause Omdurman, Sennar Granger cause Omdurman, Nyala Granger cause Omdurman. This means Omdurman market provide feedback system information and it was taken as evidence that price movements were caused by demand shocks.

Table (10): Pairwise Granger Causality Tests

Direction	Obs	F-Statistic	Prob.
NYALA does not Granger Cause ELOBIED	201	1.97462	0.1191
ELOBIED does not Granger Cause NYALA		1.40238	0.2434
OMDURMAN does not Granger Cause ELOBIED	201	1.81843	0.1451
ELOBIED does Granger Cause OMDURMAN		10.5540	**0.0006**
SENNAR does Granger Cause ELOBIED	201	2.18701	**0.0909**
ELOBIED does not Granger Cause SENNAR		1.02735	0.3816
OMDURMAN does not Granger Cause NYALA	201	0.61653	0.6051
NYALA does Granger Cause OMDURMAN		8.80793	**0.0005**
SENNAR does not Granger Cause NYALA	201	0.50396	0.6800
NYALA does not Granger Cause SENNAR		0.46910	0.7042
SENNAR does Granger Cause OMDURMAN	201	4.05312	**0.0080**
OMDURMAN does not Granger Cause SENNAR		0.39243	0.7586

3.4: Concluding Remarks:

This paper discusses the bivariate and multivariate cointegration regression results for camel prices using Engle and Granger's (1987)(Engle & Granger, 1987) test and the vector autoregression (VAR) of Johansen(Søren Johansen, 1988, 1991). The first step toward cointegration tests is the stationarity tests in which the results showed that all price series are non-stationary in level, while it was stationary in first differences for all variables and then all prices were integrated of order I(1).

In the long run the last month disequilibrium in the prices of Omdurman on Elobied corrected in the next month by 41%.

The result showed that Omdurman camel market transforms the signal of prices toward other markets in the long run concluded that these markets were cointegrated, and the system was centered on Omdurman which mean the market was demand driven in the long run.

In the short run Elobied market was affected by other markets prices but it's not affecting other markets, which may due to its geographical location.

Nyala market was affecting Omdurman and Elobied camel prices and it's not affected by others markets. This confirmed that Nyala camel market was the main source of exports which means the camel prices were supply driven in short run. The periods that camel markets need to eliminate the price shock and converge onto long-run equilibrium was fluctuated between seven and nine months, while the causality test indicated that Omdurman market provide feedback system information and it was taken as evidence that price movements were caused by demand shocks.

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