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Determinants of livestock products export in Ethiopia

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Abstract

Ethiopia has one of the largest livestock populations in Africa. In 2016–2017, the share of live animals, leather, and meat in the total export of the country reached 9.6%.
This paper aims to identify the determinants of the export of Ethiopian livestock products by means of vector autoregressive and vector error correction models.
Multivariate time series is used to model the association between the products of the Ethiopian livestock export included in the study. Vector autoregressive and vector error correction models are used for modelling and inference.
The results indicated the existence of a long term correlation between the volume of live animals, meat and leather exports. The volume of meat export is significantly affected by a lag occurring in the export of live animals in the short-run. Therefore, 3.7% of the short-run imbalance in the volume of leather export is adjusted each quarter.
It is suggested that the exporters of livestock products should properly utilise the Ethiopian livestock resources. On the other hand, the government should offer different forms of support to exporters, especially those focusing on exporting value-added products.

Key words: livestock export, VAR, VECM.

1. Introduction

Ethiopia has one of the largest livestock populations in Africa. According to recent estimates, the country has about 57.8 million heads of cattle, 28.9 million sheep, 29.7 million goats and 47.1 million poultry, plus an assortment of horses, donkeys and camels (CSA, 2015; MOA, 2015).The economic contribution of the livestock sub-sector in Ethiopia is about 11% of the total Gross Domestic Product (GDP) and 24% of the agricultural GDP (NBE, 2016).

The government of Ethiopia encourages investments in meat processing, especially focusing on exporting value-added products abroad. In 2016/17 export earnings from leather and leather products decreased by 1.1 percent due to a 1.6 percent fall in export volume despite 0.5 percent rise in international price. Consequently, the share of leather

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& leather products in total export revenue stood at 3.9% (NBE, 2016). Formally, Ethiopia exports approximately 200,000 livestock annually. Djibouti, Egypt, Somalia, Sudan, Saudi Arabia, Yemen and United Arab Emirate are the major importers of Ethiopian live animals. The key question that this paper attempts to address is "what factors determine the volume of Ethiopian livestock products export?" so this study is designed to identify factors that determine the volume of Ethiopian livestock products export. It also identifies whether there exist an association between the volume of meat, leather and live animals export or not.

Several studies about livestock products export and related variables are done using univariate time series analysis. Univariate time series analysis is important but it is inadequate for the analysis of interaction and co-movements of several time series simultaneously. In contrast, multivariate time series (MVTS) analysis involves a vector of time series that will be modelled simultaneously. MVTS deals with the interaction, co-movements and bi-directional causality of several time series. To the best of the authors' knowledge, little information (study) is available in multivariate time series analysis about livestock products export. So, this study is important in filling this gap.

2. Literature review

In their study, using monthly data disaggregated by markets of destination and sectors, Cho, Sheldon and McCorrison (2002) found that there is a strong negative impact of the exchange rate uncertainty on livestock trade compared to other sectors for a simple bilateral trade flows across countries.

The study by De Grawue and Bellefoid (1986), Steinherr (1989) demonstrates that the trade volume is more affected by the long run changes in the exchange rate than by the short run exchange rate fluctuations. This confirms the result obtained by Sheldon and McCorrison (2002).

A major problem with the leather sector is the by-product status of hides and skins. Cattle, goats and sheep are mainly used for meat (Aklilu, Yacob 2002). Thus, the product, i.e. hides and skins, becomes available when meat is needed, not when it is appropriate for leather processing. This shows the direct dependence of leather sector on meat.

Livestock are shipped across borders without letters of credit or pre-arranged sale contracts, with the trade being managed through cross-border clan relationships that face high transaction costs, including significant risks of confiscation, theft and disease as they transport and trade in animals (Wassie 2015). Somaliland exporters rely on their agents based in Yemen.

3. Data and methodology

3.1. Source and type of data

The study used secondary data obtained from the National Bank of Ethiopia over the period from 2002 first quarter to 2017 third quarter. The data have information about the quarterly volume of live animals, meat and leather export of Ethiopia; and the quarterly exchange rate.

The vector of endogenous (response) variables (Y_t) is the quarterly volume of Ethiopian livestock products export. Specifically, $Y_t = (y_{1t}, y_{2t}, y_{3t})'$, where y_{1t}, y_{2t}, and y_{3t} represents the export volume of live animals, meat, and leather at time (quarter) t, respectively. The lagged values of quarterly volume of Ethiopian livestock products are used as independent variables in our VAR specification together with the exogenous covariate quarterly exchange rate (birr against the US dollar).

3.2. Methodology

3.2.1. Vector Auto regressive (VAR) Models

The study used multivariate time series to model the association between Ethiopian livestock products export. VAR model is one of the most successful, flexible and easy to use models for the analysis of multivariate time series. It is a natural extension of the univariate autoregressive model to dynamic multivariate time series.

Stationarity

The first step for an appropriate analysis is to determine whether the time series under consideration are stationary or not. Many economic and financial time series exhibit a trending behaviour or non-stationarity in the mean. Due to non-stationarity, regressions with time series data are very likely to result in spurious results. The test of stationarity that has become widely popular over the past several years, namely, the Augmented Dickey- Fuller (ADF) test due to Dickey and Fuller (1979), is used to test for the existence of unit roots.

Since there are three endogenous variables, in this study a trivariate VAR (p) model is applied for quarterly Ethiopian livestock products export. The basic p - lag vector autoregressive (VAR (p)) model with an exogenous variable (X_t) has the form:

$$Y_t = C + \pi_1 Y_{t-1} + \pi_2 Y_{t-2} + \ldots + \pi_p Y_{t-p} + GX_t + \varepsilon_t, \quad t = 1, 2 \ldots T \tag{1}$$

where π_i are $(n \times n)$ coefficient matrices, $G \sim (n \times n)$ is a parameter matrix and ε_t is $(n \times 1)$ unobservable zero mean white noise vector process with time invariant covariance matrix Σ.

For example, a trivariate VAR (1) model with an exogenous variable (Xt) has the form:

$$\begin{bmatrix} Y_{1t} \\ Y_{2t} \\ Y_{3t} \end{bmatrix} = \begin{bmatrix} C_1 \\ C_2 \\ C_3 \end{bmatrix} + \begin{bmatrix} \pi_{11} & \pi_{12} & \pi_{13} \\ \pi_{21} & \pi_{22} & \pi_{23} \\ \pi_{31} & \pi_{32} & \pi_{33} \end{bmatrix} \begin{bmatrix} Y_{1,t-1} \\ Y_{2,t-1} \\ Y_{3,t-1} \end{bmatrix} + \begin{bmatrix} g_1 \\ g_2 \\ g_3 \end{bmatrix} X_t + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} \tag{2}$$

where $Y_t = (Y_{1t}, Y_{2t}, Y_{3t})'$ is a vector of Ethiopian livestock products export, and X_t is the exchange rate at time t. The g_i represents the effect of the current exchange rate on the contemporaneous volume of export. The diagonal elements $\pi_{i\,j}$ of matrix π represent the effect own one-period-lagged livestock product export on the respective contemporaneous export, while the off diagonal elements π_{ij} ($i \neq j$) represent the mean effects across Ethiopian livestock products export.

Estimation of the order of the VAR model

The lag length for the VAR (p) model may be determined using model selection criteria. The general approach is to fit VAR (p) models with orders p = 0,1…,P_{max} and choose the value of p which minimizes the Akaike (AIC), Schwarz – Bayesian (BIC) and Hannan – Quinn (HQ). Model selection criteria for VAR (p) models have the form:

$$IC\ (p) = \ln|\Sigma_P| + C_T.\varphi\ (n,p) \tag{3}$$

where, IC = Information Criteria, $\Sigma_P = T^{-1} \sum \varepsilon_t \varepsilon_t'$ is the residual covariance matrix from a VAR (p) model, C_T is a sequence indexed by the sample size T, and φ (n, p) is a penalty function which penalizes large VAR (p) models.

3.2.2. Co-integration Analysis

Two sets of variables are said to be cointegrated if a linear combination of these variables has a lower order of integration. For example, cointegration exists if a set of variables, each of which is integrated of order one (I(1)), have linear combinations that are I(0). The order of integration I(1) tells us that first differences transform the non-stationary variables into stationarity series. The presence of co-integration is an evidence of a long-run equilibrium relationship between the series under consideration. In this study the Johansson (1991) procedure was applied to test for the presence of cointegration relationships.

The starting point in Johansen's procedure in determining the number of co integrating vectors is re-parameterizing the VAR representation of Y_t.

$$Y_t = \pi_1 Y_{t-1} + \pi_2 Y_{t-2} + \ldots + \pi_p Y_{t-p} + DX_t + \varepsilon_t \tag{4}$$

as a vector error correction model (VECM):

$$\Delta Y_t = \pi\, Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i\, \Delta y_{t-i} + DX_t + \varepsilon_t \qquad (5)$$

where $\pi = \sum_{i=1}^{p} \pi_i - I_n$, $\Gamma_i = -\sum_{j=i+1}^{p} \pi_j$ and I_n is the identity matrix (Reinsel, 1993)

The rank of the matrix π represents the number of cointegrating vectors in the system which can be determined using the Johnson Maximum likelihood method. If the rank (π) =0, then there are

no cointegrating vectors, and we analyse the system using VAR technique by differencing the non-stationary series. If π has full rank, i.e. rank (π) = n, then Y_t has no unit root (Y_t is stationary in level). In such cases VAR methodology is applied to the system in level. Finally, if rank (π) = r, where 0 < r < n, then there exist r cointegrating vectors that are stationary, and the system is analysed as VECM.

3.2.3. Vector Error Correction Modelling (VECM)

The finding that many time series may contain a unit root has spurred the development of the theory of non-stationary time series analysis. A VEC model is a restricted VAR designed for use with no stationary series that are known to be co-integrated. It restricts the long-run behaviour of the endogenous variables to converge to their co-integrating relationships while allowing for short-run adjustment dynamics. The co-integration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

Granger's representation theorem (Granger, 1969) asserts that if the coefficient matrix π in equation (5) has reduced rank r < n, then there exist (n × r) matrices α and β each with rank r such that $\pi = \alpha\, \beta'$, where α is matrix of speed of adjustments and β is matrix of parameters which determines the co-integrating relationships matrix of long-run coefficients.

4. Results and Discussion

4.1. Time plots

The data in this study consist of log of quarterly volume (net weight) of live animal export (LLA), leather export (LLR) and meat export (LME) in tons; and the quarterly exchange rate (birr against US dollar). The time period covered is from the first quarter of 2002 to third quarter of 2017.

The time plot of each of the series is shown in Figure 1. From the time plot we can observe that even though the volume of livestock products export highly declined at different period due to the bans imposed by importing countries as a result of outbreaks of livestock diseases, all the series show an increasing trend over the study period.

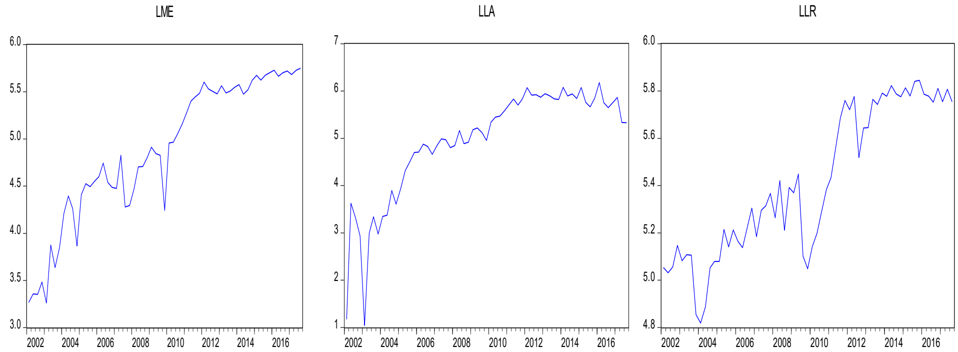

Figure 1: Time plot of the series

4.2. stationarity test

4.2.1. seasonality test

There are two reasons that might cause our data to be affected by seasonality. The first one is the quarterly nature of the data itself. Secondly, consumption of meat in Ethiopia is highly seasonal (with peaks around religious holidays), which in turn affects the export of livestock products. Therefore, before directly testing for the stationarity of the series, we have to check for the periodicity of the data. The result of seasonality test for the series is presented in Table 1.

Table 1: Seasonality test for the series

Series	F- statistic	M 7	Kruskal - Wallis statistic_(p – value)
LLA	1.942	1.955	5.776 (0.12304)
LLR	4.590	1.224	7.601 (0.05502)
LME	0.565	3.000	1.753 (0.62510)

The seasonality test results show that there is no evidence of stable seasonality for all of the series under consideration (p-value > 0.05). Moreover, the fact that the M7 statistics are all greater than one is further evidence that no seasonal adjustment is necessary (Lothian and Morry, 1978).

4.2.2. Unit root test

Before we attempt to fit a suitable model, we have to test for the presence of unit root(s) so that the order of integration of each series could be determined. The result of ADF test both at level and first difference for each series are presented in Tables 2.

Table 2: Unit root test results

Variables	At level		First difference	
	ADF statistics	P value	ADF statistics	P value
LLA	-2.519	0.317	-7.698	0.000
LLR	-1.635	0.766	-10.867	0.000
LME	-2.845	0.188	-8.704	0.000
LER	-0.040	0.950	-3.0257	0.038
Critical values (5%)	-2.9108		-2.9108	

* MacKinnon (1996) one-sided p-values.

The results in Table 2 indicate that the null hypothesis that the series in levels contains unit root could not be rejected for all of the four variables, while the null hypothesis is rejected for the first difference of the series. This implies that the time series under consideration are all integrated of order one (I (1)).

4.3. VAR model specification and estimation

For subsequent modelling choices, specifying the lag length has strong implications. The lag order selection results indicated that the appropriate lag length for the VAR model is one (1). Furthermore, the Wald lag exclusion test shows that the chosen lag is optimal and suitable for the data set. Accordingly, we adopt VAR (1) model for prediction and forecasting purposes.

Table 3: Vector auto regression estimates

Standard errors in ( ) , t-statistics in [ ] & p-value in {}

Specification	D_LLA	D_LLR	D_LME
D_LLA(-1)	-0.255833 *	-0.005862	-0.098513 *
	(0.11103)	(0.02736)	(0.05327)
	[-2.30422]	[-0.21425]	[-1.84922]
	{0.0173}	{0.8233}	{0.0453}
D_LLR(-1)	-0.356147	-0.260173 *	-0.147339
	(0.52483)	(0.12934)	(0.25182)
	[-0.67860]	[-2.01154]	[-0.58510]
	{0.4798}	{0.0373}	{0.5423}
D_LME(-1)	0.238370	0.079182	-0.241890 *
	(0.27461)	(0.06768)	(0.13176)
	[0.86803]	[1.17001]	[-1.83580]
	{0.3663}	{0.2237}	{0.0471}
C	0.028549	0.013864	0.040123
	(0.06441)	(0.01587)	(0.03090)
	[0.44325]	[0.87343]	[1.29831]
	{0.6442}	{0.3633}	{0.1772}
D_LER	1.679694	-0.224150	2.512451
	(5.01018)	(1.23473)	(2.40396)
	[0.33526]	[-0.18154]	[1.04513]
	{0.7268}	{0.8500}	{0.2769}

* represents significant variables.

The volumes of live animal, leather and meat export are significantly explained by their own past volume of export. This implies that for a percent increase in one time lagged volume of live animal and leather export their volume of export is decreased by 0.255 and 0.26 percent respectively.

The volume of meat export is also explained by past volume of live animal export; a one percent increase in one-time lagged volume of live animal leads to a 0.24percent decrease in the volume of meat export. This result is in line with the findings of Gebergziaher (2015).

4.4. Co-integration analysis

Since the variables are integrated of the same order, we proceed to co integration test. The main purpose of co- integration analysis is to model the long-run relationship between the underlying variables. The results of c-integrating tests for LLA, LME and LLR are reported in Table 4.

Table 4: Johansen co-integration test results

Number of co integrating vector	Eigen value	Trace test			Maximum eigenvalue test		
		Statistic	critical value	Prob.**	Statistic	critical value	Prob **
None *(**)	0.255284	33.13406	29.79707	0.0199	28.87368	21.13162	0.0033
At most 1	0.172862	15.15419	15.49471	0.0562	11.15595	14.26460	0.1466
At most 2(**)	0.056959	3.577366	3.841466	0.0586	5.335259	3.841466	0.0209

Normalized co integrating coefficients (standard error in ( ) and t-statistic in [ ])

LLA	LLR	LME
1.00000	5.267334	-3.909227
	(1.43794)	(0.62645)
	[3.66312]	[-6.24032]

* for Trace test and (**) for maximum eigen value test.

From the Johansen co-integration test, the rank of the co-integration matrix was found to be one. In other words, there is one linear combination of the three I(1) series that is stationary, that is, there exists a long-run causal relationship among LLA, LLR, LME. A study by Gebergziaher (2015) also reports that there is a long-run association between livestock export.

The long-run model is given by:

$$LLA = 3.91\ LME - 5.27\ LLR - 14.39$$

The long-run equation shows that a one percent increases in the volume of meat export induces, on average, an increase of about 3.91 percent in the volume of live animals in the long-run.

4.4.1. Model estimation

Having concluded that the series under consideration are cointegrated, we proceed to estimate the short-run behaviour and the adjustment to the long-run equilibrium, which is represented by VECM. The results of the fitted VEC model are presented in Table 5 below.

Table 5: Vector error correction estimates

Standard errors in ( ) & t-statistics in [ ]

Error Correction:	D(LLA)	D(LLR)	D(LME)
CointEq1	-0.104701	-0.037182 *	0.047054
	(0.06410)	(0.01538)	(0.03085)
	[-1.63344]	[-2.41777]	[1.52542]
D(LLA(-1))	-0.201626 *	0.013388	-0.122875 *
	(0.108564)	(0.02743)	(0.05502)
	[-1. 857206]	[0.48806]	[-2.23321]
D(LLR(-1))	-0.162598	-0.191439	-0.234323
	(0.53058)	(0.12730)	(0.25534)
	[-0.30645]	[-1.50386]	[-0.91770]
D(LME(-1))	-0.022891	-0.013599	-0.124475
	(0.31434)	(0.07542)	(0.15128)
	[-0.07282]	[-0.18031]	[-0.82284]
C	0.044204	0.019423	0.033087
	(0.06419)	(0.01540)	(0.03089)
	[0.68865]	[1.26122]	[1.07111]
D_LER	0.056511	-0.800585	3.241934
	(5.03619)	(1.20830)	(2.42362)
	[0.01122]	[-0.66257]	[1.33764]

* represents significant variables

The results of the fitted VEC model show that the volume of meat export is significantly affected by lagged value of the volume of live animals export in the short-run. Furthermore, the vector error correction models show that 3.7% of the short-run disequilibrium in the volume of leather export is adjusted within one quarter, while the remaining shocks are adjusted in the subsequent quarters. On the other hand, the volume of live animals export is significantly affected by its own lagged values in the short-run.

4.4.2. Structural analysis

4.4.2.1. Forecast error variance decomposition

The decomposition is used to understand the proportion of the fluctuation in a series explained by its own shocks as well as shocks from other variables. The results of the decomposition analysis are presented in Table 6 below.

Table 6: Variance decomposition of LLA

Variance Decomposition of LLA:				
Period	S.E.	LLA	LLR	LME
1	0.835363	100.0000	0.000000	0.000000
2	1.105118	92.88874	3.624653	3.486603
3	1.259070	88.09384	5.049786	6.856373
4	1.347530	85.30358	5.599132	9.097284
5	1.397888	83.72305	5.835364	10.44158
6	1.426325	82.83517	5.947145	11.21769
7	1.442299	82.33809	6.003622	11.65829
8	1.451243	82.06030	6.033349	11.90636
9	1.456240	81.90521	6.049381	12.04541
10	1.459029	81.81868	6.058150	12.12317

At the first horizon, the variation of live animals export is explained by its own shock only. In the second quarter, shock to the volume of live animals export accounts for 93% variation of the fluctuation in live animals export (own shock) and the remaining 3.6 and 3.4 percent is explained by the volume of meat and leather exports, respectively. Then after shock to the volume of live animals, leather and meat export account approximately for 82%, 6% and 12% of the variability in the volume of live animals export, respectively.

5. Conclusions

In this empirical work, an attempt was made to apply multivariate time series analysis to model the co integration of Ethiopian livestock products export using quarterly data from 2002 to 2017. The data were tested for seasonality and results revealed that all of the series were not affected by periodicity. Moreover, unit root tests show that all four series were non-stationary in level, but stationary after first differencing.

Among all candidate VAR models, VAR (1) was found to be the best to describe the data. The co-integration test shows that there exists a long-run association between the volumes of Ethiopian live animals, leather and meat export.

The long-run equation shows that the volume of live animals export has a positive long-run relationship with the volume of meat export: for a one percent increase in the volume of meat export, the volume of live animals export is increased by 3.9 percent, in the long-run. One naturally expects an inverse relationship between the two. But the finding that the two series drift upward together may support the fact that the Ethiopian livestock resource is underutilized.

From the fitted short-run models, 3.7% of the short-run disequilibria in the volume of leather export are adjusted each quarter. The volume of meat export is significantly affected by lagged volume of live animals export in the short-run. On the other hand, the volume of live animals export is significantly affected by its own lagged values in the short-run.

It is recommended for concerned bodies to properly utilize the Ethiopian livestock resource. It is also recommended to include more exogenous factors (such as fuel oil price and domestic price of meat).

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