



Volatility and cointegration in export of livestock and marine products of India

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ABSTRACT

This study was carried out to examine the instability and volatility in the export of livestock and marine products of India. It was found that marine export was a bit more stable and less volatile compared to livestock products export. Further, cointegration between the two was also tested. It was concluded that the two export data series were cointegrated. One of its benefits is that the long-run equilibrium relationship can be modelled by a straightforward regression involving the levels of the variables. Finally, the forecast were also obtained, which were quite reliable.

Key words: GARCH, Instability, Livestock products, Marine products, Volatility

Global trade negotiations and domestic reforms of various kinds on many different aspects of livestock sector improved the access of India to international markets to a large extent, particularly during the post-WTO period (Kumar 2010). Also owing to this, export of livestock and marine products show a high degree of fluctuations characterised by sudden rise and abrupt fall. This is what is called volatility and it seems to be the norm rather than an exception now-a-days in International market (Jaffee 2005). This may be due to structure of trade, climatic conditions, and rapidity with which producers can respond to price changes. The exports of many agricultural commodities show a great degree of fluctuations. This is because of delays between production decisions and delivery to the market. Kumar *et al.* (2012) examined the performance of buffalo meat export from India and also assessed its competitiveness; and showed that there has been a commendable increase in the export of buffalo meat from India during the last two decades.

Statistically, volatility is often measured as the sample standard deviation. Sometimes, variance, σ^2 , is also used as a volatility measure. Moreover, to test for volatility in time-series datasets ARCH-LM test statistics has also been developed. To model volatility in time-series data Generalized autoregressive conditional heteroscedastic (GARCH) family of parametric nonlinear time-series models were proposed. GARCH estimates the conditional volatility of volatile data generating processes thereby helping the planners to make proper policy decisions.

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Hence, analysis of volatile data like the export of livestock and marine products assumes considerable significance in formulating a robust policy. In this paper we study instability as well as the volatility present in the datasets pertaining to livestock and marine products. Subsequently, the time-series data under consideration is also fitted using GARCH model. Another important feature of financial time-series data is the presence of cointegration, where each series are nonstationary independently but a linear combination of them becomes stationary. In this study, we also test for presence of cointegration phenomenon in the 2 time-series data and carry appropriate statistical measure for the same.

MATERIALS AND METHOD

The study is based on time-series data of monthly export of livestock and marine products in India available at www.indiastat.com, which shows considerable fluctuations leading to volatility. The behaviour of such volatile products is fundamental to policy makers to make proper and robust planning to face risk in the future arising due to volatility.

The ratio method, which estimates standard deviation in the ratio of current price to its one-step lag, was used in the study. The export instability was estimated by carrying out this method.

Export instability index (I_e) = standard deviation of

$$\log \left(\frac{E_t}{E_{t-1}} \right) * 100$$

where, E is the export and t and t-1 denote the months and its lag. Similar study was carried out by Kumar and Rai (2011) to study the trends and volatility in domestic and international prices of livestock products in India.

In the early stages of time-series analysis, main interest

was to find a model which could explain effectively the mean behaviour of data (Box *et al.* 2008). Recently, concerns about volatility in the data has been raised because patterns in volatility are observed in real datasets. Volatility may vary considerably over time: large (small) changes in returns are followed by large (small) changes. Thus modelling and forecasting of volatility are crucial for financial markets. Out of many approaches available in the literature for modelling volatile data sets, one approach is the promising methodology of GARCH family of parametric nonlinear time-series models.

The GARCH model can be written as

$$\varepsilon_t = \xi_t h_t^{1/2}$$

and

$$h_t = a_0 + \sum_{i=1}^q a_i \varepsilon_{t-i}^2 + \sum_{j=1}^p b_j h_{t-j}$$

where $\xi_t \sim \text{IID}(0,1)$, $a_0 > 0$, $a_i > 0$, $i = 1, 2, \dots, q$, $b_j > 0$, $j = 1, 2, \dots, p$

There are many procedures available in the literature for parameter estimation of GARCH. One method is the Gaussian maximum likelihood estimation procedure available in E-Views software which will be applied in our analysis.

Another important economic measure usually encountered in financial time-series data is the presence of cointegration between 2 or more nonstationary time-series data. In such situations, the results indicated that many of the apparently significant relationships between nonstationary economic variables in existing econometric models could well be spurious. So, appropriate measures are to be taken up to carry out meaningful statistical analysis.

In this paper, we tested the hypothesis that there is a statistically significant connection between the livestock export and marine export by testing for the existence of a cointegrated combination of the 2 series.

If two nonstationary time-series y_t and x_t are cointegrated, a linear combination of them must be stationary. In other words:

$$x_t - \alpha y_t = \varepsilon_t$$

where ε_t is stationary.

This is done by the Engle-Granger two-step method where, is estimated by using ordinary least squares and it is tested for stationarity by using the Dickey-Fuller test.

RESULTS AND DISCUSSION

Export instability of livestock and marine products: The monthly export data of livestock and marine products of India from June 2006 to June 2012 available at www.indiastat.com were analysed to find the instability in each of these products. The export data of both livestock and marine products exhibited large variation which can be concluded by the high value of instability index of 22.31 and 20.14 respectively.

A comparative figure of instability in monthly export of livestock and marine products of India is presented in Table 1. The inter-month variations in export of livestock products

were comparatively higher than marine export (Table 1). The monthly instability trends also showed higher variations in the year 2007 for marine products as well as livestock products

Table 1. Inter-month variation of export data

Inter-month variation for the year	Livestock	Marine
2006	15.52	16.89
2007	31.82	30.74
2008	21.08	19.44
2009	15.66	16.07
2010	24.04	20.97
2011	19.65	18.45
2012	15.22	13.44

Table 2. Descriptive statistics of export data

Livestock		Marine	
Mean	606.26	Mean	832.60
Median	457.35	Median	724.11
Maximum	1643.60	Maximum	1997.75
Minimum	176.83	Minimum	365.11
Std. Dev.	358.03	Std. Dev.	370.95
Skewness	1.12	Skewness	1.17
Kurtosis	3.35	Kurtosis	3.97
Jarque-Bera	15.97 (0.0003)	Jarque-Bera	19.46 (0.00006)

The maximum value of export is roughly 10 times the minimum in the case of livestock export (Table 2). And for marine export the maximum is roughly 5 times the minimum. So in this case ARIMA time-series modelling cannot be applied. Moreover a perusal of data showed high volatility at many time-epochs. So, to capture the volatility in the 2 series we used the GARCH nonlinear time-series modelling available in EViews software package, Ver. 4.

The fitted model for livestock data from June 2006 to December 2011 is given by

$$y_t = 1137.44 + 0.60y_{t-1} + 0.34y_{t-2} + \varepsilon_t$$

(661.50) (0.19) (0.18)

where $\varepsilon_t = h_t^{1/2} \xi_t$, and h_t satisfies the variance equation

$$h_t = 520.28 + 0.15 \varepsilon_{t-1}^2 - 1.00h_{t-1}$$

(157.27) (0.01) (0.07)

The fitted model for marine export data June 2006 to December 2011 is given by

$$y_t = 941.61 + 1.05y_{t-1} - 0.272y_{t-2} + \varepsilon_t$$

(128.52) (0.07) (0.15)

where $\varepsilon_t = h_t^{1/2} \xi_t$, and h_t satisfies the variance equation

$$h_t = 890.7635 - 0.15 \varepsilon_{t-1}^2 - 0.92h_{t-1}$$

(277.73) (0.05) (0.07)

The values in the parentheses denote the corresponding standard errors of the estimates.

To study the appropriateness of the fitted models, the autocorrelation function of the standardized residuals and squared standardized residuals are computed. It was found that, in both situations, the autocorrelation function was insignificant at 5% level of significance, thereby conforming that the mean and variance equations are correctly specified.

The graph of fitted models along with data points are exhibited in Figs 1 and 2, which indicated that the fitted models are able to capture the volatilities present in the data to a reasonable good extend.

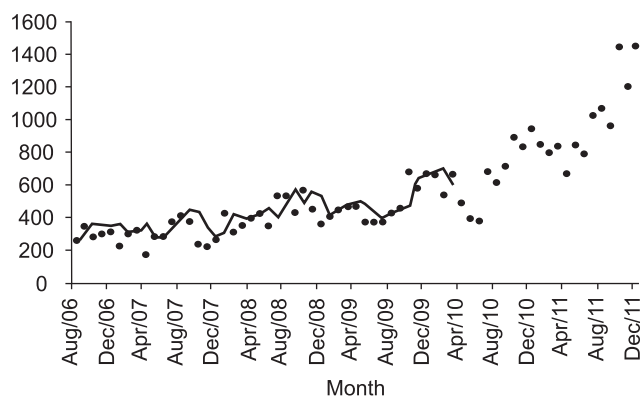


Fig. 1. Fitted GARCH Model along with the livestock export data points

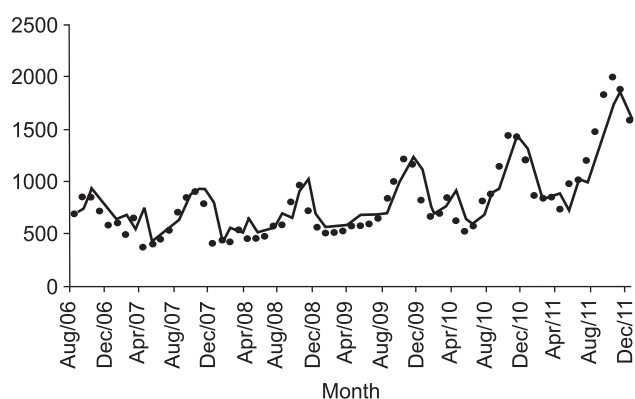


Fig. 2. Fitted GARCH Model along with the marine export data points.

The sudden burst followed by sudden downfall in the export may be attributed to the cyclical pattern in the growth of the world economy and also movements in the production of these commodities, since livestock and marine products both are believed to be income elastic. For instance the rising trends in export of livestock and marine products after April 2011 may be attributed to the fact that there was sudden increase in the demand from many importing countries like China and South East Asia due to their high growth in their economy. Further, the whooping income realized from the inflated oil prices aided a strong import demand in the Middle East and North African countries for the livestock and marine products.

Carrying out the Dickey-Fuller test at 5% level of significance for testing the presence of unit root in the 2 data generating process, we concluded that the livestock export as well as marine export is both nonstationary as we fail to reject the null hypothesis of presence of unit root. The main problem now is that statistical inference associated with stationary processes is not valid if the time series are nonstationary processes. Though differencing could lead to stationarity of the time-series, much information including that of the level series would be lost and moreover Economic theories are generally postulated for levels of variables rather than for differences.

To this end, we go for the Engle-Granger 2-step method for testing the presence of cointegration between the series. This is carried out in Matlab 2007a software package and we conclude that the two series are cointegrated and they share a common stochastic drift. Moreover the regression coefficient was 0.587 when marine product was taken as the dependent variable while regression coefficient as 1.05 when livestock was taken as the dependent variable with extremely low p value in both the cases. So, this shows that though the two time-series are nonstationary, there linear combination is stationary.

Forecasting performance: Forecasting performance for 6 data points corresponding to All-India data of monthly export of livestock and marine from January, 2012 to June, 2012 as hold-out-data is studied. One-step ahead forecasts are computed and reported in Tables 3, 4.

Table 3. One-step ahead forecasts of livestock export data (₹ crore)

Months	Actual	Forecast
Jan-12	1,643.6	1,554.43
Feb-12	1,284.7	1,398.47
Mar-12	1,295.08	1,283.57
Apr-12	1,173.62	1,212.82
May-12	1,394.54	1,306.82
Jun-12	1,331.18	1,342.75

Table 4. One-step ahead forecasts of marine export data (₹ crore)

Months	Actual	Forecast
Jan-12	1,299.42	1,151.05
Feb-12	1,089.06	1,003.37
Mar-12	1,115.84	1,087.94
Apr-12	1,082.86	1,045.66
May-12	1,242.12	1,224.11
Jun-12	1,326.38	1,271.45

To sum up, the livestock and marine export data shows high instability. This can be concluded by its high instability index. It also showed abrupt rise and fall which gave insight into the volatility present in the data. The volatility was satisfactorily modelled and forecasted using GARCH

model. Moreover, it was seen that the 2 export time-series data, though nonstationary, were cointegrated. The presence of cointegration will be beneficial in modelling the long-run equilibrium relationship of the two series.

REFERENCES

- Box G E P, Jenkins G M and Reinsel G C. 2008. *Time Series Analysis: Forecasting and Control*. 4th edn. Prentice Hall, USA.
- Engle R F and Granger C W J. 1987. Co-integration and error-correction: Representation, estimation and testing. *Econometrica* **55**: 251—76.
- Jaffee S. 2005. *Delivering and taking the heat: Indian spices and evolving product and process standards*. Agriculture and rural development discussion Paper **19**. The World Bank, USA.
- Kumar A and Rai D C. 2011. Trends and volatility in domestic and international prices of livestock products in India. *Indian Journal of Animal Sciences* **81** (12): 1248–52.
- Kumar A, Jee S and Yadav C. 2012. Export of buffalo meat from India: performance and prospects. *Indian Journal of Animal Sciences* **82** (12): 1578–83.
- Kumar A. 2010. Exports of Livestock Products from India: Performance, Competitiveness and Determinants. *Agricultural Economics Research Review* **23**: 57–67.
- Poon S H and Granger C W J. 2003. Forecasting volatility in financial markets: A review. *Journal of Economic Literature* **41**: 4