An Analysis of different forecasting models for prices of coconut products in Sri Lanka

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Abstract

Instability of prices of coconut and coconut products is a well-known phenomenon in Sri Lanka during the last decade. Therefore, an appropriate forecasting model of prices is needed for producers, consumers and policy makers. Objective of the study was to find an appropriate model to forecast coconut and allied products in Sri Lanka. Published data of coconut prices of Coconut Development Authority (CDA) and Central Bank of Sri Lanka (CBSL) for the period 1974 to 2004 were used for the analysis. Time series plots were used to find major behavioral patterns. If the data series were non-stationary, first order differences were taken. Further, first order differences of log-transformed series were taken, if the data series were non-stationary after having first differences. Stationary data series were fitted to six conventional time series models, viz; General decomposition method, Moving average method, Winter's method, Single exponential smoothing method, Double exponential smoothing method, and Auto regressive moving average (ARIMA) method. Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD), Mean Squared Deviation (MSD) were used to test the model adequacy and accuracy. The results revealed that the ARIMA & exponential methods are better than other models to predict prices of coconut and coconut products in Sri Lanka.

Key Words: Coconut, Price analysis, Time series Models

Introduction

Coconut has been the third most important commercial crop of Sri Lanka since the colonial era. Sri Lanka is the world's fourth largest producer of coconut, covering a total acreage of 394836ha. In 2003, its contribution to the GDP was 1.2 %, while agricultural contribution to the GDP was 17.9 % (CBSL, 2004) .The average annual coconut production is around 2500 million nuts, of which around 65% is used for household consumption. The rest is mainly used by two industries; desiccated coconut (DC) and coconut oil. The former is export oriented, and the latter caters mainly to the domestic market. Besides product diversification, range of coconut prices also exist. Coconut products may deal with a number of prices in the market channels: such as retail prices, wholesale prices, auction prices, FOB prices, CIF prices. All these prices are undergone to fluctuation making a grate risk of investing, buffer stock maintaining, making future contracts, and in international trade and other associated actions. One common and powerful tool to overcome above problems is prediction of future prices through sophisticated and scientific forecasting model. Various methods of forecasting techniques are used to predict future prices in the world (Gujarati, 2003). Scope of this study was to find an appropriate forecasting model for prices of coconut and selected coconut products, and to support to formulate national coconut price policies in the country.

Methodology

Data required for the study were extracted from monthly bulletins of Coconut Development Authority (CDA), Socio Economic Statistics published by Central Bank of Sri Lanka and the data bank of Asian Pacific Coconut Community (APCC). National average prices of desiccated coconut, coconut oil, average wholesale and retail prices of fresh coconut from January 1974 to December 2004 were considered for the analysis.

Time Series (TS) plots were used to find the major behavioral patterns against the time factor. When the preliminary information extracted from the TS plots, the data were checked for the stationary. If the data series shows non-stationary pattern, the first order differencing method was used as the first attempt to convert it into a stationary series. If the data series was not achieved the stationary after taking first differences, it was transformed using log transformation method and then found first order differences (Madridakis *et al*, 1983). The series of transformed data were analyzed using six standard time series models; viz; General decomposition method, Moving average method, Winter's method, Single exponential smoothing method, Double exponential smoothing method and Auto regressive moving average (ARIMA) method. In order to find the Seasonal (monthly) indices, the de-trended data series was smoothed by using a

centered moving average of order twelve. As the seasonal cycle length is an even number, this actually requires a two-step moving average in order to synchronize the moving average correctly (Gujarati,2003). After the moving average was obtained, it was subtracted from the detrended data to obtain raw seasonal values. Within each seasonal period, the medians of the raw seasonal values were calculated. These medians made up the seasonal indices. Following criteria were used to find the fitness of the model (Ljung and Box, 1978).

The Mean Absolute Percentage Error (MAPE) which measures accuracy as a percentage of the fitted values of time series models.

$$\text{MAPE} = \frac{\sum |(y_t - \hat{y}_t)/y_t|}{n} \times 100 \qquad (y_t \neq 0)$$

Where yt = = actual value; $\tilde{Y}$= forecasted value; and n = number of forecasts.

The Mean Absolute Deviation (MAD) which measures the accuracy of fitted time series values. It expresses accuracy in the same units as the data and helps to conceptualize the amount of error.

$$\text{MAD} = \frac{\sum_{t=1}^{n} |y_t - \hat{y}_t|}{n}$$

Where Yt = the actual value; $\tilde{Y}$ = forecasted value; and n = number of forecasts.

The Mean Squared Deviation (MSD) which is very similar to Mean Squared Error (MSE), a commonly-used measure of accuracy of time series models.

$$\text{MSD} = \frac{\sum_{t=1}^{n} (y_t - \hat{y}_t)^2}{n}$$

Where Yt = the actual value; $\tilde{Y}$ = the forecasted value; and n = the number of forecasts.

Results and Discussion

This section discusses mathematical explanations of behavior of prices of the four commodities considered - fresh coconut, coconut oil and desiccated coconut – in the study. Though the behavioral pattern of a price line is decided by marketing factors, the help which can gain through fitting a mathematical model is not diminutive, as it can predict future prices and make the decision making process easier.

From the time series plot for retail prices for the period 1974 to 2004 (Figure 1a), two distinct regions could be identified. The region-1 begins from the origin of the data set (1974) and spreads out to year 1983, and the region-2 begins from there itself and stretches to the end of the data set. The region-1 has comparatively lower trend (Yt = 0.187181 +0.0146*t) while region-2 shows a steeper upward movement, which is approximately four times higher than that of region-1, (Yt = -3.37656 + 0.0484*t). Not only region-1 and two are different from their gradients but also they show different amplitudes of fluctuations of prices. Up to the year 1983, the fluctuation is lower while after the year 1983 it shows a "crest and collapse" pattern. It can also be seen that almost all the peaks occur in January or adjacent months. In the first quarter of the year 1980, an abnormal vibration could be identified.

Figures 2a, 2b, 2c and 2d show the seasonal indices of prices of all selected commodities for the period considered in the study. Figure 2a and 2b not only expose the seasonal pattern of price fluctuation of retail and wholesale prices but also it tells some important phenomena about those markets. As both indices show the same pattern in the same lag, it is obvious that price signals move fast from the wholesaler to retailer. From the months of November to April, retail market has comparatively higher prices, while in wholesale markets, peaks of prices are from December to March. So, wholesalers buy the product for cheaper price in November and April and sell at higher price. Therefore it seems wholesalers maximize their profit margin in the Sinhala and Hindu New Year period and in the Christmas Seasons. Fluctuations are very mild in prices of coconut oil and desiccated coconut (Figures 2c and 2d) and they are remarkably more stable than that of fresh coconut. It characterizes the reason why the investment in primary markets is more risky than that is in secondary markets.

Log transformation and first order differencing can be used to make the series stationary. After removing the heteroskedasticity from the data set, analysis was carried out to find the best-suited time series model for the retail price. Figure 3a shows the actual and predicted values for the data set analyzed using the general decomposition method, the moving average method, the Winter's additive method, the single exponential smoothing method and the ARIMA method. Table 1 shows comparisons between five models using MAPE, MAD and MSD.

The ARIMA model is better than 12th order moving average model as it has less MAPE, MAD and MSD values. The Winter's additive model is also better than the moving average model but not good as ARIMA model. The Single exponential smoothing model is the best model among all the models tested for forecasting prices of coconut as indicated in table-1.

Table 1: Comparison of different forecasting models for coconut retail price

Model	MAPE	MAD	MSD
General decomposition method	32.21	0.258	0.114
12th order moving average model	39.625	0.201	0.066
Winter's additive model	30.385	0.148	0.034
Single exponential smoothing model	15.646	0.076	0.013
ARIMA model	15.694	0.076	0.013

Time series plot for wholesale prices from year 1974 to 2004 is shown in Figure 1b. The two regions, which were seen in time series plot of retail prices, exist in this graph too. Similar to Figure 1a, the region-1 extends up to year 1983 and the region-2 starts from there. In order to go for an in-depth analysis natural log transformation was carried out. Sudden change of behavior after 1983 can be seen here as well. Six models namely the general decomposition method, the 12th order moving average model, the Winter's additive model, the single exponential smoothing model, and the ARIMA model were used to analyze log transformed and first order differenced wholesale prices. The Figures 3.b plots the actual and predicted prices using above models. The MAPE, MAD and MSD used to compare models. Single exponential smoothing model is better than the 12th order moving average model as it has less MAPE, MAD and MSD values. The Winter's additive model is also better than the moving average model but not as good as single exponential smoothing model. Least accurate model is the general decomposition method. Table 2 shows a comparison between six models for the wholesale data. In wholesale prices also, single exponential smoothing model and ARIMA models provide higher accuracy and the remaining models have comparatively lower accuracy, which was the case in retail price too.

Table 2: Comparison among different forecasting methods for coconut wholesale price

Model	MAPE	MAD	MSD
General decomposition method	4.059	0.297	0.149
12th order moving average model	3.194	0.237	0.091
Winter's additive model	2.196	0.163	0.042
Single exponential smoothing model	1.092	0.082	0.012
ARIMA model	1.123	0.084	0.136

Time series plot for coconut oil prices from year 1974 to 2004 is shown in Figure 1c. Two distinct regions of the plot can be identified in this graph also; the first region from 1974 to 1983, and he second, spiky region after 1983. Moreover, a sudden unrealistic price drop in 1986 had an effect on the stationary of the model even after log transformation. Figure 3c shows the log transformed values and estimated values of five models. Table 3 gives the MAPE MAD and MSD of each method used.

Table 3: Comparison among different forecasting methods for coconut oil price

Model	MAPE	MAD	MSD
General decomposition method	3.045	0.293	0.147
12 order moving average model	2.236	0.217	0.085
Winter's additive model	1.721	0.167	0.050
Single exponential smoothing model	0.684	0.067	0.013
ARIMA model	1.753	0.745	0.017

Time series plot for Desiccated coconut (DC) prices from year 1974 to 2004 is shown in Figure 1d. Two regions as in the case of all these previous price analyses could be observed here too. Log transformation has applied as a remedial measure to correct the non-stationary. All the methods which used to analyze other three commodities were used in DC analysis too. Figure 3d shows the log transformed values and fitted values by using all the models as in other analysis.

Table 4 gives the MAPE, MAD and MSD of each method.

Table 4: Comparison among different forecasting methods for prices of desiccated coconut

Model	MAPE	MAD	MSD
General decomposition method	2.644	0.253	0.115
12 order moving average model	1.999	0.194	0.062
Winter's additive model	1.404	0.135	0.031
Single exponential smoothing model	0.626	0.061	0.007
ARIMA model	0.698	0.072	0.009

Conclusion

Magnitude of seasonal fluctuation of prices of fresh coconut, coconut oil and desiccated remarkably higher in the period after the year 1983 compared to the previous period. Similarity of Seasonal indices of wholesale and retail prices and their patterns revealed that the market integration is considerably strong in coconut sector. However, the variability of prices of coconut oil and desiccated coconut was less compared to that of fresh coconut indicating need of transfer from trade of raw materials to a sort of finished products. Increasing trend of prices of all coconut products were significantly higher for the period after the year 1983 compared to preceding period. Among all forecasting models tested, the ARIMA & Exponential smoothing methods were found better than other models to predict prices of coconut and coconut products in Sri Lanka as they have the lowest MAPE, MAD and MSD.

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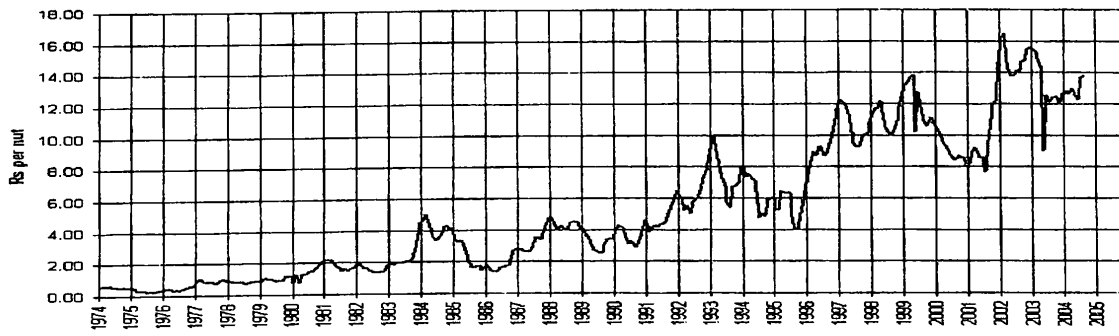
Appendix

Figure 1a: National average nominal price (Rs. per nut) of fresh coconut from Year 1974 to 2005
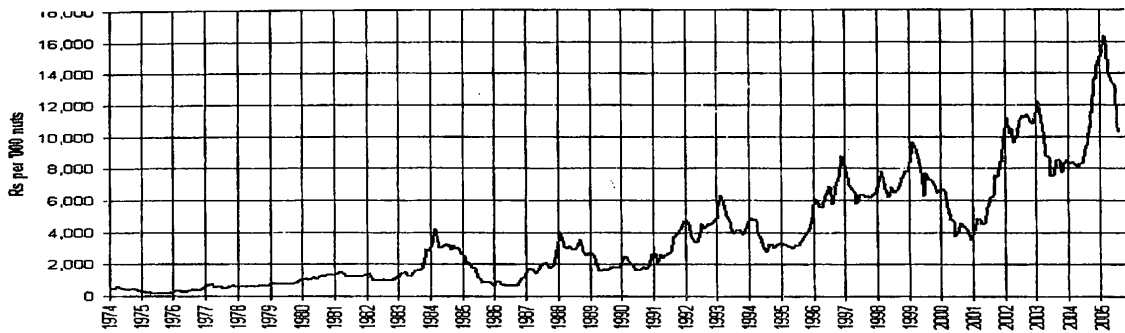

Figure 1b: National average nominal price (Rs. Per 1000 nut) of fresh coconut from Year 1974 to 2005
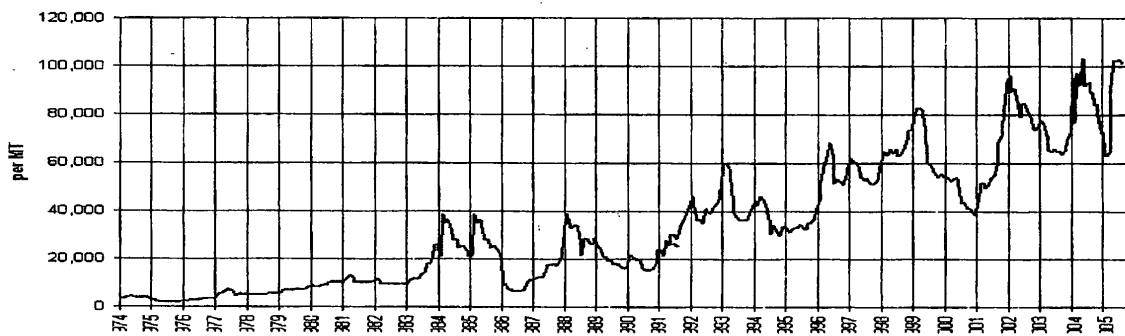

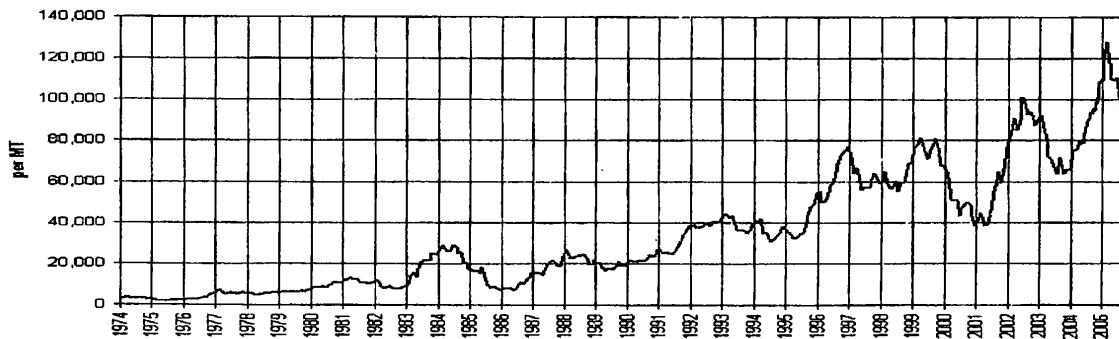Figure 1c: National average nominal price (Rs. Per Mt) of coconut oil from Year 1974 to 2005

Figure 1d: National average nominal price (Rs. Per Mt) of desiccated coconut from Year 1974 to 2005
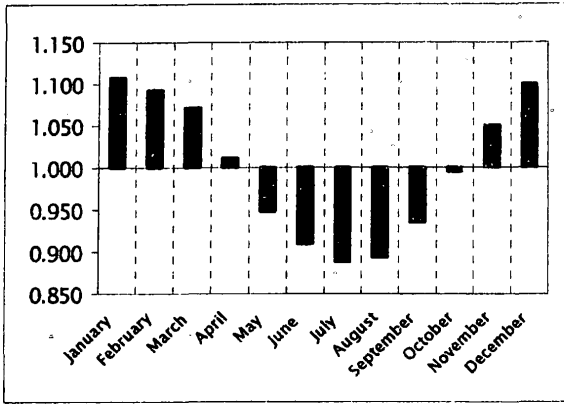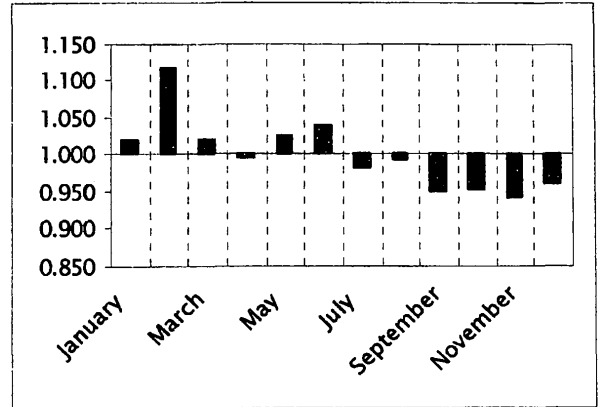
Figure 2a: Seasonal Indices of prices of retail prices of fresh coconut

Figure 2c: Seasonal Indices of prices of coconut oil
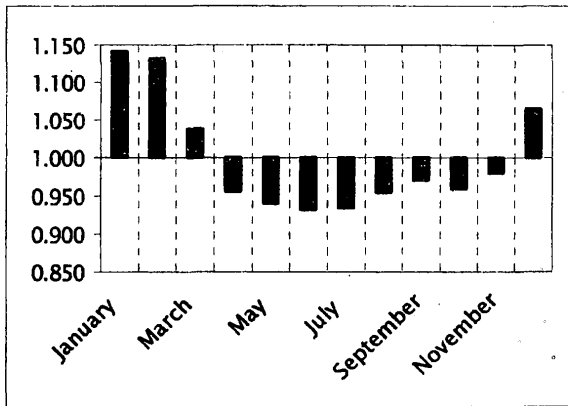
Figure 2.b: Seasonal Indices of prices of fresh Coconut
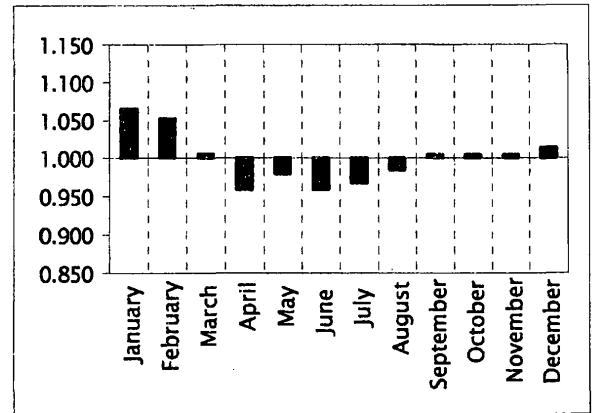
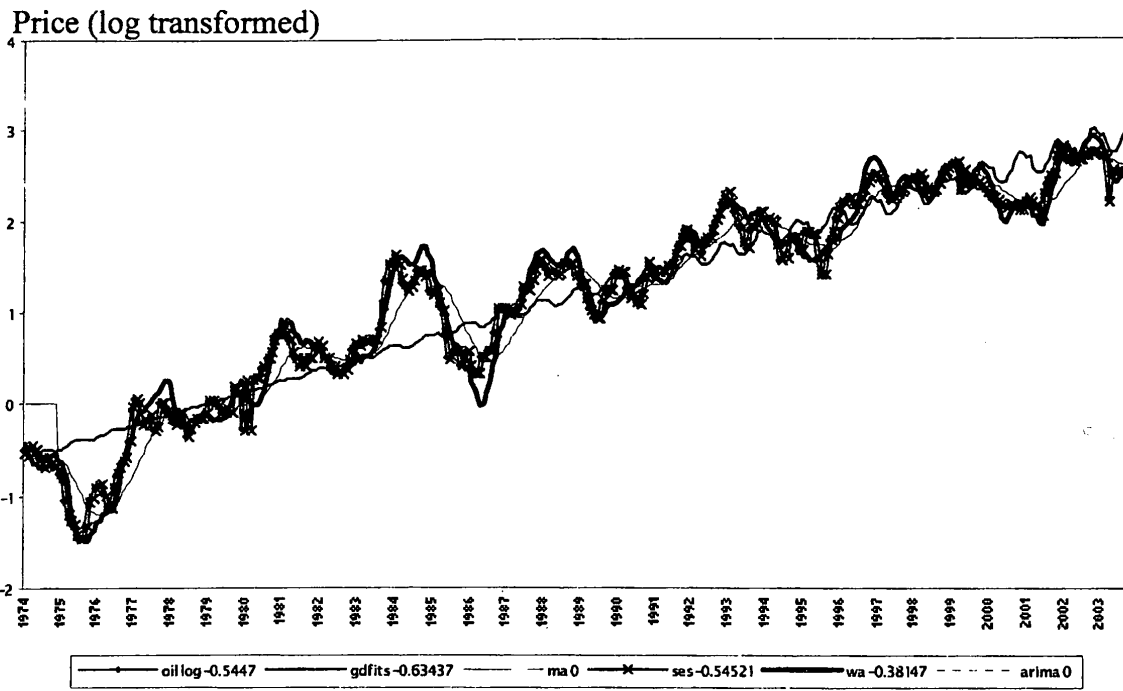Figure 2.d: Seasonal Indices of prices of desiccated coconut

Price (log transformed)

Figure 3a: Time series plot for retail prices and predictsed prices of fresh coconut by five selected time series models
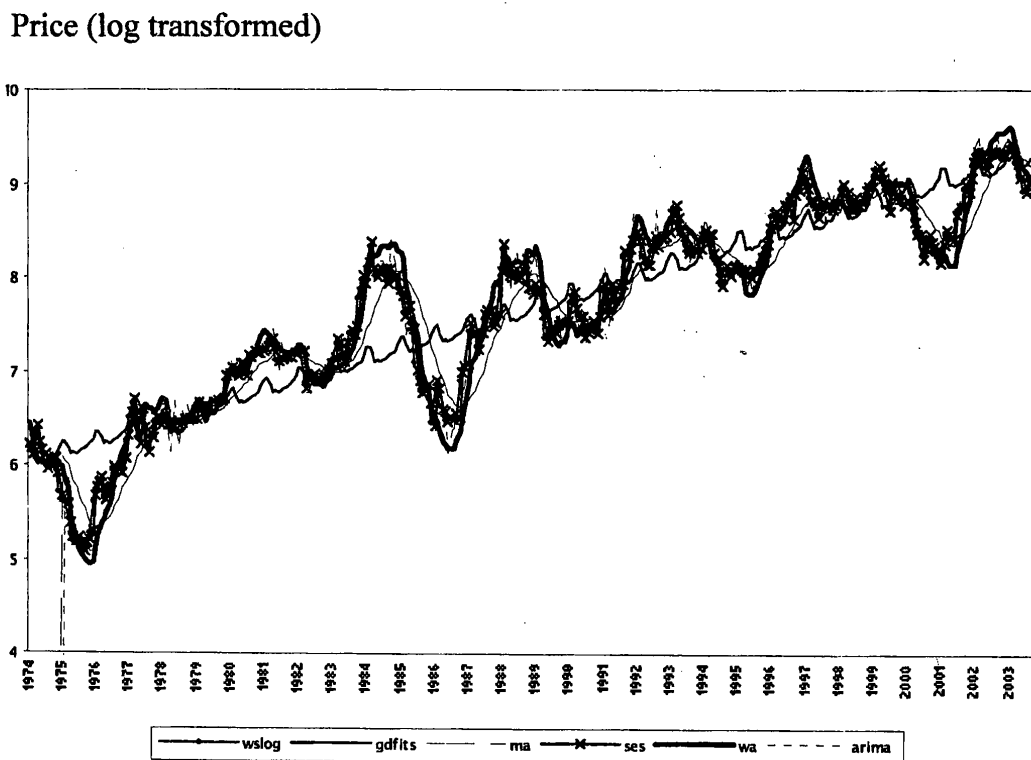
Price (log transformed)

Figure 3b: Time series plot for actual and predicted prices of wholesale prices of fresh coconut
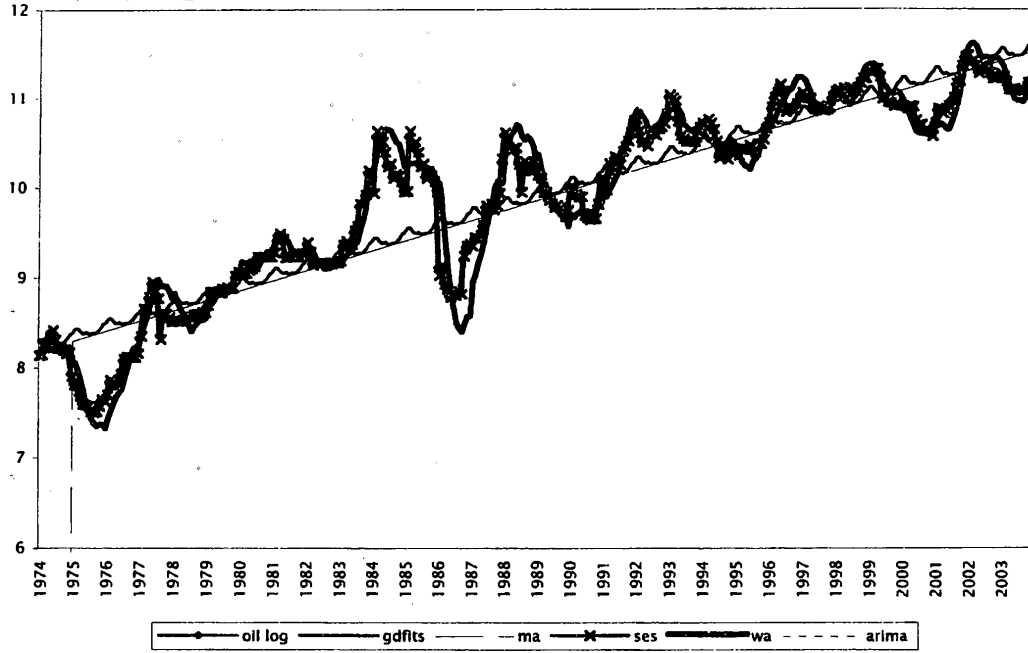
Price (Rs.) Log transformed

Figure 3c: Time series plot for actual prices and predicted values of prices of coconut oil
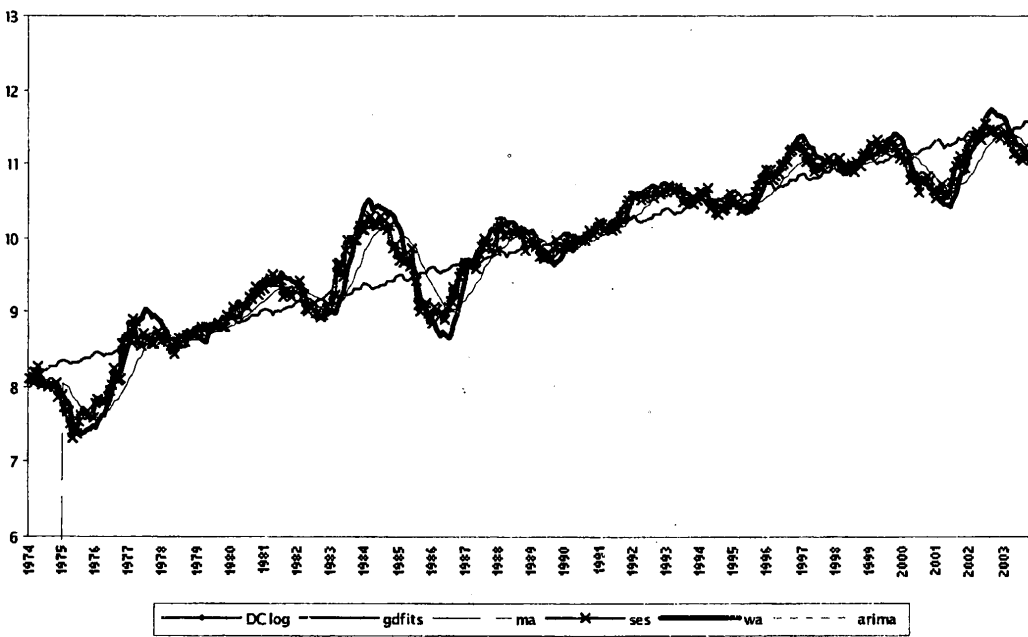
Price (Rs.) Log transformed

Figure 3d: Time series plot for actual and predicted prices of prices of desiccated coconut