Challenges for Indian Agriculture and Non - Gaussian Time Series Models for Agricultural Crop Prices

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ABSTRACT

India being a pre-dominantly agricultural country, agricultural crops form the major factors contributing to the Gross Domestic Product (GDP). The author reviews and develops various non-Gaussian as well as non-linear time series models for prices of agricultural crops. The study also aims at predicting future prices, so as to enable the scope of agricultural crops as profitable means of cultivation. Another aspect is to assess the global threats and reasons for the decline in prices in the post liberalization period in India. We also give special emphasis on the external factors consequent to India's adherence to the W.T.O. agreement and suggest some remedial measures to make Indian agricultural sector profitable to the farmers as well as the nation.

In Part1, a detailed analysis of the GATT rules and multilateral agreements, which are relevant to natural rubber and coconut, is done. An insight into the developments in the international market and various policy initiatives during the last decade is done. The need for productivity enhancement, effective production, quality improvement for export competitiveness, steps to be taken for value addition of rubber, etc are pointed out. It is found that the price of coconut oil depends on the prices of other vegetable oils. The coconut industry in the world is always susceptible to the pressure from low oil seed prices and increased availability of cheap oils like palm oil, soybean oil etc. The widespread incidence of coconut mite and root wilt disease as well as recurring drought during recent years affected coconut sector to a great extent. Rather than W.T.O. effects, lack of productivity and adequate market connectivity, outdated trading practices, etc caused havoc in this sector. However, the tea, coffee, pepper, cardamom etc are facing serious problems.

In Part 2, we have developed some non-Gaussian time series models. It was found that most data on agricultural crop prices/indices are marginally non-Gaussian and hence time series models

with non-Gaussian marginal distributions are to be developed for proper modeling. First order autoregressive models are sufficient and parsimonious in modeling agricultural crop prices/indices. Models with marginal distributions like Cauchy, Stable, Linnik, Geometric Linnik, Generalized Laplace, Marshall-Olkin Exponential and Weibull distribution are appropriate in this regard. Non-linear models like AR(p)–ARCH(q) models can best reflect the volatility and changing conditional variances. The best non-Gaussian time series model for agricultural crop prices is one with Generalized Laplacian marginals. Cauchy and Linnik autoregressive models are also satisfactory. With regard to modeling volatility and varying conditional variances with regard to time, ARCH models are more suitable. Only short term forecasts are meaningful as prices depend on various non-random extraneous factors like govt. policies at national and international levels. Also some computer programs are developed for simulating the models and estimating the parameters. In the concluding section, the findings and conclusions are summarized.

Keywords: ARCH Models, ARMA Models, WTO regime, Natural Rubber, Coconut.

1. Introduction

The changed economic order in the context of globalization and liberalization of world trade in agriculture has opened up new vistas of growth. Spices sector is one of the key areas in which India has an inherent strength to dominate the global markets. The world's romance with Indian spices continues unabated. India is the largest producer, consumer and exporter of spices in the world. The present annual production of spices in India is 3.0 million tons from over 2.5 million hectors. About 8.5% of India's export earnings from agricultural and allied products come from spices. India is a significant exporter of spices and plantation produces.

India occupies the 3rd position in production and 4th in consumption and 1st in terms of productivity of Natural Rubber (NR). Of the global production of 71.1 lakh MT India's share is only 6.4 lakh MT in 2002. The annual growth is at the lowest at 0.08%. Kerala accounts for 84% of the rubber production in India. In India about 1.89 million hector of land is under coconut cultivation. At the rate of 6776 nuts per hector India produces about 12822 million nuts a year. Though the share of Kerala state was 56% in 91-92 the share has come down to 48% in 2001 and 2002. The productivity has also come down to 5895 nuts per hector. The major products are coconut oil and coir products. India contributes 25% of the world pepper production with about 3.2 lakh million tons in 2002.

Since agriculture is always at a loss, the area under cultivation of many crops is declining. The productivity of all the crops is showing a slowing trend. It's also a fact that we produce comparatively more but do not realize proportionate revenue from these commodities in the international market. In view of the existing open market approach under the provisions of World Trade Organisation rules coupled with the Regional Trade Agreements it is apprehended that free flow of these commodities from international markets would badly affect the farm economy of the country. Though market access for our commodities to international markets is technically feasible, technical barriers to trade might become an impediment unless they are professionally addressed to at the right time through appropriate mode. Though all these commodities are not covered under the Agreement on Agriculture of WTO, there are GATT negotiations on these.

2. WTO and Agricultural Crops in India: Challenges and Opportunities

The rigorousness of the applicable WTO disciplines increase manifold if they are agricultural products as compared to the 'non-agricultural'. Non-agricultural products in the WTO, are not the same as industrial products and include products and product groups which traditionally or in context of other international agreements/ understandings are agricultural. The prime examples being products like natural rubber, coir, jute and even fishery or marine products. This is so because the WTO Agreement on Agriculture (AOA) applies on a list of products specifically

mentioned in the Annex to that Agreement. By default therefore, any product that is not included in the Annex to the AOA, such as those mentioned above, fall within the ambit of the 'general' provisions of GATT and related WTO agreements.

The main agricultural products of concern in this study are: (i)Coconut & products such as copra and coir, (ii)Natural Rubber; (iii)Spices – pepper, cloves and cardamom; (iv)Cashew; (v)Tea; (vi) Coffee.Here we attempt to raise certain issues of concern to India's negotiating position/ options in WTO for these products/ product groups. Identification of possible developmental mechanisms and their examination under applicable WTO disciplines is necessary to throw up crucial development issues that need to be examined and debated. Formulation of a coherent and comprehensive policy structure for the long-term development of supply capacities in India of these products is only possible through such a structured approach.

2.1 Natural Rubber

Kerala holds a share of 92% in Natural Rubber production in India. World trade in natural rubber both in terms of the main suppliers and the main importers or users is very well defined and limited.Thailand, Indonesia,Malayasia, Singapore,Ivory Coast,USA, India constitute the principal suppliers of natural rubber.The principal importers are USA,China,Japan,Malayasia and Korea. Of these China imposes 20% MFN applied Tariffs where as USA, Japan and Malayasia do not impose this tariff.

Other than tariffs, the important WTO disciplines that apply to the trade of natural rubber are the possible non-tariff barriers – in terms of standards and other technical requirements - and the subsidies that may be provided by other exporting countries. Finally, an issue for discussion would be the implications under WTO agreements of possible development measures that the States and Central Government in India may put in place for the development of the industry. It may be verified that tariffs are not the most significant barriers to trade, the applied tariffs in the main markets are fairly low, ranging from 0% to 20%. Since this is also the range for the bound tariffs in these countries, the scope for negotiating the reduction of these tariffs for further improvement in the market access is limited. The present applied tariffs in India, which are amongst the highest in the main producing and exporting countries, is affording the needed protection in the domestic market for the present.

The main issue concerning Natural Rubber in India is the volatility of the international price of rubber, making it difficult to formulate a steady and long term policy. Unlike other major producers like Malaysia, Indonesia and Vietnam, where substantial state support for exports are provided no such structured incentive is provided for rubber exports from India. Governmental attempts at price stabilization has also at best had mixed results and difficult to justify as a continuous policy support mechanism, particularly when the international prices move up. The alternative to market interventions is a sustained and long term WTO compatible development policy for the sector without a specific focus on exports. This would promote a competitive industry in general.

2.2 Issues of concern

Natural Rubber in India is treated as an agricultural product, but in the WTO it is not covered by the disciplines of the Agreement on Agriculture (AOA). A move seeking renegotiation in product coverage will require significant negotiating capital – and just re-designating Rubber as an agricultural product will not allow India the right to enhance the present bound rates. For enhancing the bound rates on several agricultural tariff lines including rice and wheat, India had to negotiate under the Article XXVIII of GATT 1994 and pay significant compensation to the affected countries. This intervention is urgently needed since rubber prices had reached the lowest level of Rs.90/- per kg in the global as well as Indian markets in January 2016.

There is a need for balancing the consumer interest of NR users in India with that of the producers. Therefore, prohibitive import duties will not be supportable in the long run. The solution has to be targeted towards the sustained development of the Rubber industry. In addition to W.T.O. effects, there are various external factors, which influenced the prices of agricultural crops in recent years. As far as rubber sector is concerned the main factors are low productivity and lack of value addition. Non-exposure to export market, devaluation of Indian rupee during 1991 and Asian economic turmoil caused decline in prices. Demise of INRA (International Natural Rubber Agreement), removal of port restrictions and quantity restrictions, accumulated surplus, decline in international price, non-inclusion under AoA and treating NR as a non-agricultural crop, treating NR as an industrial raw material, lack of cost efficiency, slow down in the internal demand of NR since 1996-97 etc had their impacts.

Measures to reduce adverse effects in the rubber sector are inclusion under AoA, enhancing bound rate of tariff and infrastructure strengthening for quality improvement. Promotion of rubber wood, as an eco-friendly plant, giving subsidy for rubber export, providing a level playing field for NR growers, re-categorization of rubber as an agricultural product, imposing antidumping duty etc are some other measures. Procurement and buffer stocking through STC, NAFED etc, Promoting group action through Rubber Producers Societies (RPS), avoiding import of rubber products, providing strategic market information support, enhancing productivity, investment for productivity increase and cost effective production, promoting rubberization of roads, using rubber wood as construction timber, developing value addition techniques, incentives for quality improvement, certification and packaging and transportation and periodic review of market situations are needed.

In the case of coconut, low price of other vegetable oils, minimum level of demand, recurring drought, endemic and epidemic outbreak of pests and diseases etc are the various external factors, which caused the havoc. Dependence on coconut oil driven market alone, middle level trade practices, coconut mite infestation, drastic decline in production and lack of oil market connectivity affected this sector to a large extent. Non-inclusion under AoA and fear of cholesterol in coconut oil had adverse effects.

As remedial measures we should evolve policies focused on competitiveness through higher productivity, reduction in cost of production and better adoption of cultivation practices at farmer's level. It is necessary to find ways and means to put coconut into other alternative uses like tender coconut as soft drink, edible copra, desiccated coconut, coconut cream etc. Value addition and by-product utilization, effective utilization of land through mixed cropping in order to increase productivity and net return, integrated disease management for effective controlling of eriophyid, mite, root wilt disease, leaf rot disease, bud rot disease, stem bleeding disease etc. can help a lot. Post harvest processing methods are to be modernized for ensuring quality. The full economic potential of coconut and related products like coir, shell based handicrafts, etc are to be explored. Regulation of import, readjustment in tariff, promotion of coconut oil as an edible oil, diversification of products, promotion of sweet toddy as a health drink and jaggery making, promotion of tender coconut water as a soft drink, using coconut oil as a lubricant oil are some other steps. Coconut development projects, continuation of minimum support, price stabilization and productivity, enhancing production and productivity, expansion of area under coconut, integrated farming, new technologies for food and beverage industries etc are necessary.

Thus to achieve competitiveness in the liberalized era we have to reorient the production process towards global market rather than domestic market. One has to be proactive with the changing consumer preferences and market conditions in the global market. We have to attain global competitiveness in cost of production and value chain process and create a brand image by supplying only quality products. We have to boost spices production and ensure quality. Import of low-grade spices to India and re-export of mixed (Indian and foreign) under the Indian label should be banned.

3. Non-Gaussian Time Series Models for Crop Prices Data

Now we develop time series models for modeling time series data on agricultural crop prices. We develop non-Gaussian AR(1) time series models in Cauchy and Generalized Laplacian variables. Usual normal ARMA models are also developed. Since observed prices arise in a time sequence, it is possible that the consecutive observations are dependent. Therefore a time series model based approach has been tried to explain the fluctuations other than trend and seasonal variations. A fairly good estimate of the parameters of the series is obtained only if the series is stationary. Plotting of the original data shows that it is not stationary. Therefore, for further analysis, we take a first order difference of the prices given by $Z_n = X_n - X_{n-1}$.

Firstly we try to model the prices using the Box Jenkin's (BJ) method. In this technique a model can be fitted to data by studying the behavior of the characteristics such as ACF and PACF or by using some Information criteria like AIC. After identifying order and nature of the relationships, the model parameters are to be estimated. These models can be used for short term forecasting, because most of the autoregressive models place emphasis on recent past rather than its distant past.

As part of this study we will construct ARMA models and in special Auto Regressive (AR) Processes. An ARMA (p, q) model has the general form

$$X_t = a_0 + a_1 X_{t-1} + \ldots + a_p X_{t-p} + \varepsilon_t + b_1 \varepsilon_{t-1} + \ldots + b_q \varepsilon_{t-q}$$

The simplest AR process is the AR(1) model having the structural equation

$$X_n = a X_{n-1} + \varepsilon_n \; ; \; |a| < 1.$$

where $\{\varepsilon_n\}$ is a sequence of independent identically distributed (i.i.d.) random variables, independent of distributed (i.i.d.) random variables, independent of $X_0, X_1, \ldots, X_{n-1}$. We can obtain the structure of the innovation process $\{\varepsilon_n\}$.More details including the properties of are available in Brockwell & Davis (2002).

As part of this study we have developed different non-Gaussian Auto Regressive processes. The autocorrelation function and partial autocorrelation function along with Akaike Information Criterion (AIC) led to the conclusion that AR(1) models are sufficient to model the data on crop prices to a satisfactory level.

ARCH models

In conventional econometric models the variance of the disturbance term is assumed to be constant. However, most economic time series like price data exhibit periods of unusually large volatility followed by periods of relative tranquility. We assume a time dependence on conditional variances through an autoregressive equation for the squared innovations. This led us to construct Auto-Regressive Conditionally Hetroscedastic models.

An AR(p)–ARCH(q) model has the general form given by the structural equation

$$X_n = a_0 + a_1 X_{n-1} + \ldots + a_p X_{n-p} + \varepsilon_n$$

where $\{\varepsilon_n\}$are distributed as normal with means zero and conditional variances given by

$$h_n = b_0 + b_1 \varepsilon^2_{n-1} + \ldots + b_q \varepsilon^2_{n-q} + \nu_n$$

where $\{\nu_n\}$ is a white noise process.

The details are summarized as follows.

3.1 Some non-Gaussian Time series models

(i) An Auto-regressive Model with Cauchy innovations

Consider the AR(1) model

$$X_n = aX_{n-1} + \varepsilon_n ; \ |a|<1 \qquad (1)$$

where $\{\varepsilon_n\}$ is i.i.d. and independent of $\{X_{n-1}\}$. In terms of characteristic functions, equation (1) can be rewritten under the stationary case as

$$\varphi_X(t) = \varphi_X(at)\,\varphi_\varepsilon(t)$$

$$\therefore \quad \varphi_\varepsilon(t) = \varphi_X(t)/\varphi_X(at) \qquad (2)$$

Consider the Cauchy distribution whose characteristic function is

$$\varphi_X(t) = e^{-|t|}$$

Substituting in (2), we get the characteristic function of the innovation process as

$$\varphi_\varepsilon(t) = e^{-(1-|a|)t}$$

Hence the p.d.f. of $\{\varepsilon_n\}$ is another Cauchy density.

(ii) etric Stable Processes

In this case also the innovations are also distributed as symmetric stable.

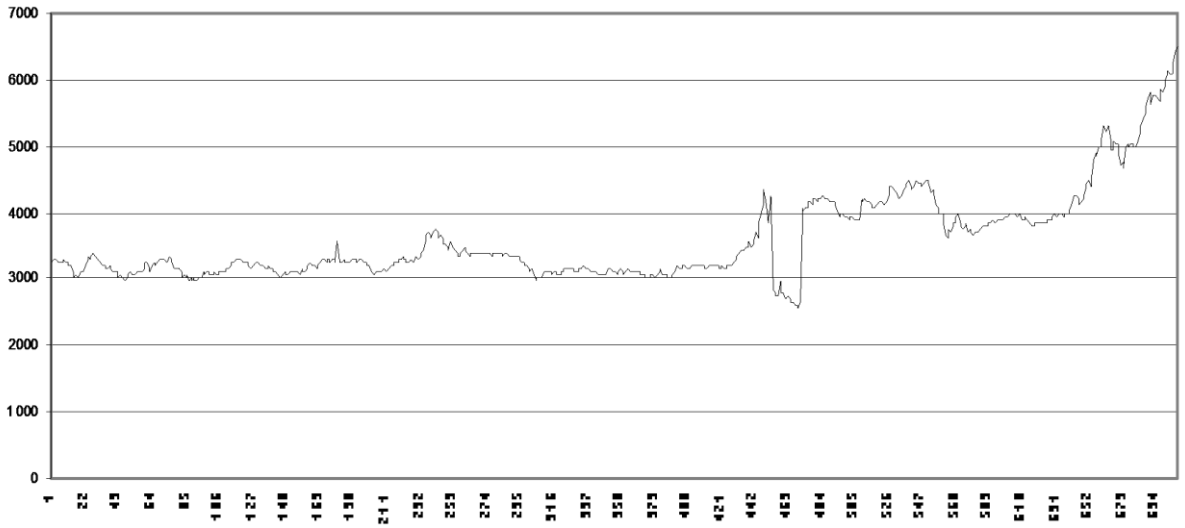
(iii) Generalized Laplacian Processes

The generalized Laplacian random variable being the difference of Gamma random variables is the sum and difference of a number of exponential random variables. It has wide flexibility and can model data from various contexts having a growth-decay structure. Agricultural crop prices can be regarded as the net effect a number of positive and negative factors. Hence a generalized Laplacian autoregressive process may be most appropriate in this context. The innovation distribution can be derived easily as before.

3.2 A Cauchy model for Coconut prices

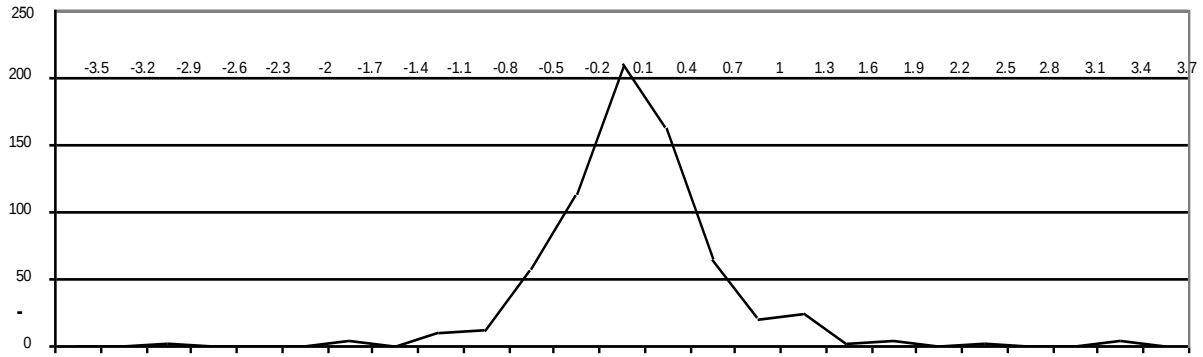
We apply the Cauchy model developed above to model a set of data consisting of daily coconut oil prices (in Indian Rupees per quintal) at Cochin market for a period from January 1994 to December 1996. The analysis is mainly concerned with the price recorded on each trading day.

Time series plot of Coconut Oil Prices (1993-96)



The time series plot of the original data shows an increasing trend while the differenced series is stationary. So it is convenient to analyze the changes in the successive prices. Let X_n be the original price on the day 'n', then we make the transformation $Z_n = (X_n - X_{n-1}) / \sigma (X_n - X_{n-1})$, where $\sigma (X_n - X_{n-1})$ is the standard deviation. For testing normality, we use Geary's (Cooper and Weeks (1988)) test statistic G, which is the ratio of the mean deviation to the standard deviation. The G-statistic for the transformed values of the coconut oil prices is G = 0.4956 and hence we reject the hypothesis that the underlying distribution is normal.

Frequency curve of the transformed coconut oil prices



The figure suggests that the other possible distributions may be Cauchy, generalized Laplace, Linnik etc as we are dealing with the price data. To confirm the applicability of the distribution we have to test the goodness of fit. The transformed data is symmetric about zero. Goodness of fit test concludes that the transformed sequence follows a Cauchy distribution.

Finally we get the model $Z_n = 0.033277\ Z_{n-1} + \varepsilon_n$, where $\{\varepsilon_n\}$ is a sequence of independent and identically distributed random variables which follows Cauchy C(0.966723,0) distribution .

3.3 ARMA and ARCH Models for Coconut Oil Prices

In this section we develop various time series models for coconut prices/indices. In order to achieve stationarity we make the following transformation. If X_t is the price at time t, the first order difference is $Z_t = X_t - X_{t-1}$. The first order differences are labeled as 'dprice'. In the case of coconut and rubber we analyze both prices and wholesale price indices. The data on prices is monthly prices of coconut at Cochin market.

Since the AIC and RSS for all the models are not much different the most parsimonious model is the AR(1) model given by

$Z_t = 22.921 + 0.3088\ Z_{t-1} + \varepsilon_t$

where $Z_t = X_t - X_{t-1}$ and $\{\varepsilon_t\}$ is the innovation process. The innovations may be assumed as following distributions like Linnik, stable, Cauchy, Laplacian, generalized Laplacian etc.

In a similar manner AR(2), ARMA (1,1), ARMA (2,1), ARMA (2,2) models can be constructed. The fitted ARMA model is

$Z_t = 19.509 + 1.736\ Z_{t-1} - 0.9976\ Z_{t-2} + \varepsilon_t + 1.70224\ \varepsilon_{t-1} - 0.9976\ \varepsilon_{t-2}$

Since the AIC and RSS for all the models are not varying much we conclude that the most parsimonious model is the AR(1) model given by

$Z_t = 1.19964 + 0.34036\ Z_{t-1} + \varepsilon_t$.

For the coconut oil prices data, we get the AR(1) – ARCH (1) model given by

$Z_t = 22.921 + 0.3088\, Z_{t-1} + \varepsilon_t$

where $\{\varepsilon_t\}$ are distributed as normal with mean zero an conditional variances given by

$h_t = 19.4308 + 3.2083\, \varepsilon^2_t + 0.2122\, \varepsilon^2_{t-1} + \nu_t$

where $\{ \nu_t \}$ is a white noise process. Using the models developed we can predict the future values of the process. This method can be used for obtaining forecast and confidence limits for the future values of the series. Similarly we can develop AR-ARCH models for pepper, tea, and cashew prices as follows.

The AR(1) – ARCH (3) model for pepper price indices is $Z_t = 7.1813 - 0.3880\, Z_{t-1} + \varepsilon_t$ where $\{\varepsilon_t\}$ are distributed as normal with mean zero an conditional variances given by $h_t = 3.1435 + 326.0578\varepsilon^2_t + 0.6210\, \varepsilon^2_{t-1} + 0.2143\, \varepsilon^2_{t-3} + \nu_t$ where $\{ \nu_t \}$ is a white noise process.

The AR(1) – ARCH (3) model for tea price indices is $Z_t = 1.15963 + 0.19433\, Z_{t-1} + \varepsilon_t$

where $\{\varepsilon_t\}$ are distributed as normal with mean zero an conditional variances given by

$h_t = 2.7698 + 285.4655\varepsilon^2_t + 0.5540\, \varepsilon^2_{t-1} + 0.2844\, \varepsilon^2_{t-3} + \nu_t$ where $\{ \nu_t \}$ is a white noise process.

The AR(1) – ARCH (3) model for cashew price indices is $Z_t = 1.30989 + 0.19557\, Z_{t-1} + \varepsilon_t$

where $\{\varepsilon_t\}$ are distributed as normal with mean zero and conditional variances given by

$h_t = 1.1594 + 47.6680\, \varepsilon^2_t + 0.3887\, \varepsilon^2_{t-1} + 0.0791\, \varepsilon^2_{t-3} + \nu_t$ where $\{ \nu_t \}$ is a white noise process.

4. Conclusions

The paper makes a detailed analysis of the various problems faced by Indian agriculture in the new liberalized era under W.T.O. regime and points out the challenges ahead. The economics of globalization is based on Ricardo's principle of comparative advantages. Our comparative advantage is mainly in the field of agriculture. It should always be remembered that the only means of success under the W.T.O. regime of liberalization are increased productivity, high quality and value addition.

The new time series models developed can be used for short-term predictions only since agricultural prices depend on government policies and various other factors. Problems like proper data warehousing and management, developing advanced statistical tools, diagnostic checking, statistical inference, developing more efficient algorithms etc are problems for further research

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