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Estimation of onion production in India using structural time-series model

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ABSTRACT : A univariate structural time series model based on the traditional decomposition into trend, seasonal and irregular components is defined. Purpose of present paper is to discuss STM methodology utilized for modelling time-series data in the presence trend, seasonal and cyclic fluctuations. Structural time series models are formulated in such a way that their components are stochastic, *i.e.* they are regarded as being driven by random disturbances. A number of methods of computing maximum likelihood estimators are then considered. These include direct maximization of various times domain likelihood function. Once a model is estimated, its suitability can be assessed using goodness fit statistics and model used to predict for five leading years. In present study the model was developed for onion production, from the forecasting available. The results showed that forecastd area and production increased in the next five year.

Key Words : Structural time series model, Forecast, Kalman filter, Goodness of fit

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ARIMA time series methodology is widely used for modelling time-series data. This methodology can be applied only when either the series under consideration is stationary or it can be made so by differencing, de-trending, or by any other means. Another disadvantage is that this approach is empirical in nature and does not provide any insight into the underlying mechanism. An alternative mechanistic approach, which is quite promising, is the structural time series modelling (Harvey, 1996). Here, the basic philosophy is that characteristics of the data dictate the particular type of model to be adopted from the family. Purpose of present paper is to discuss STM methodology utilized for modelling time-series data in the presence of trend, seasonal and cyclic fluctuations. Structural time series models are formulated in such a way that their components are stochastic, *i.e.* they are regarded as being driven by random disturbances. Forecasts are made by extrapolating these components into the future. Harvey and Todd (1983) compare the forecast made by a basic form of the structural model with the forecast made by ARIMA models and conclude that there may be strong arguments in favour of using structural models in practice. Structural models are applicable in the same situations where Box-Jenkins ARIMA models are applicable; however, the structural models tend to be more informative about the underlying stochastic structure of the series. In another paper Harvey (1985) show structural models can be used to model cycle in macro economics time series. Other studies included Kitagawa and Gersch (1984). The forecast obtained from particular model depend on certain variance parameter.

The key to handling structural time-series models is the state space form, with the state of the system representing the various unobserved components, such as trend, cyclical or seasonal fluctuations. Once in state space form (SSF), the Kalman filter provides the means of updating the state, as new observations become available. Once a model is estimated, its suitability can be assessed using goodness fit statistics. Onion area ('000 Mill. ha) and production ('000 MT) in India data for the period of 1978-79 to 2011-2012 were analyzed by structural time series model used to forecast for five leading years.

Research Procedure

The study mainly confined to onion area and production of India. The secondary data of area and production on Onion of 34 year were collected for period 1978-79 to 2011-12. Data collected from Department of Agriculture and Cooperation, Government of India were subjected to analyze through structural time series model. The data were analyzed by using software like MS-EXCEL and statistical analysis system (SAS). Structural time series model was adopted to observe the forecast model, the model used was:

Structural time series model for trend:

A structural time series model is set up in term of its various components, like trend, cyclic fluctuations and seasonal variation, *i.e.*:

$$Y_t = T_t + C_t + S_t + £_t \quad \text{...... (1)}$$

where,

Y_t is the observed time-series at time t, T_t, C_t, S_t, ε_t, are the trend, cyclical, seasonal and irregular components.

Local level model (LLM):

In the absence of seasonal and cyclical components, eq. (1) reduce to:

$$Y_t = «_t + £_t, £_t \sim N(0, ±_£^2), t = 1, 2... T,$$

where,

$$«_t = «_{t-1} + \ _{t-1} + ¦_t \text{ and } \ _t = \ _{t-1} + £_t$$

Goodness of fit:

Goodness of fit statistics is used for assessing over all models fit. Basic measure of goodness of fit in time series model is prediction error variance. Comparison of fit between different models is based on Akaike information criterion (AIC):

$$AIC = -2 \log L + 2n,$$

where,

L is the likelihood function, which is expressed in term of estimated one-step-ahead prediction errors $\tilde{\upsilon}_t = Y_t - \hat{Y}_{t/t-1}$. Here n is the number of hyper parameters estimated from the model. Schwartz-Bayesian information criterion (BIC) was also used as a measure of goodness of fit which is given as:

$$BIC = -2 \log L + n \log T,$$

where,

T is total number of observations. Lower the value of these statistics better is the fitted model.

RESEARCH ANALYSIS AND REASONING

Onion area ('000 Mill. ha) and production ('000 MT) in India data for the period of 1978-79 to 2011-2012 were analyzed by structural time series model used to predict for five leading years.

Forecasting with structural time-series model:

Structural time series models were developed basically to forecast the corresponding variable. To judges the forecasting ability of the fitted model important measure of the sample period forecasts accuracy was computed. The AIC for onion area and production to be obtained 84.07 and 93.49, respectively (Table 1). The BIC for onion area and production to be obtained 79.67 and 97.89, respectively. Onion area forecast for the year 2017 to be about 1.434 million hectare with upper and lower limit 1.68 and 1.18 million hectares, respectively. Forecast of onion production for the year 2017 to be about 22.28 million tonnes with upper and lower limit 26.68 and 17.88 million tonnes. From Table 2 it is observed that the forecasts using structural time series model showed an increasing trend for area and production of onion in India. The validity of these forecasts can be checked when the actual data is available for the lead years. Forecasts for the future

Table 1: Trend information

Name	Intercept	Slop	AIC	BIC
Area	1.03	0.079	84.07	79.67
Production	15.70	1.31	93.49	97.89

Table 2: Forecast for India's total onion area and production

Year	Area ('000 Mill ha)		Production ('000 MT)	
	Forecast	Standard error	Forecast	Standard error
2013	1.11	0.057	17.02	0.92
2014	1.19	0.070	18.33	1.16
2015	1.27	0.087	19.65	1.47
2016	1.35	0.106	20.96	1.83
2017	1.43	0.129	22.28	2.24

years from 2013 to 2017 by using the structural time series models are presented Table 2.

Conclusion:

In the present study the structural time-series model was developed for onion area and production, from the forecasting available by using the developed model, it can be seen that forecasted onion areas and production increased in the next five years. The validity of the forecasted value can be checked when the data for the lead periods become available. The model can be used by researchers for forecasts onion areas and production in India. However, it should be updated from time to time with incorporation of current data. From the above forecasts for the lead periods showed that there was a small change in the forecasts of area and production of onion in India. There is a need to adopt the high yielding varieties of onion and improved package of practices for increasing the production of onion in India.

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