# Structural Time-Series Models for Forecasting Yield of Promising Varieties of Rice Crop in Chhattisgarh

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***ABSTRACT***

*A univariate structural time series model based on the traditional decomposition into trend, seasonal and irregular components is measured. Purpose of present paper is to discuss Structural Time Series Model (STM) methodology utilized for modelling time-series data in the present of trend, seasonal and cyclic fluctuations. Structural time series model are formulated in such a way that their components are stochastic, i.e. they are regard as being driven by random disturbances. The study mainly confined to secondary collected for a period 2009-10 to 2014-15 data of promising varieties of Rice yield. As these techniques, it may be mentioned that models are fitted to the data and coefficient parameter value obtained on the basis of the model are compared with the actual observation for assessing the accuracy of the fitted model. To validate the forecasting ability of the fitted models, for the three years with upper and lower limit. The maximum rice yield obtained Swarna variety with forecast for the year 2017-18 obtained 50.31 q/ha with upper and lower limit 53.84 and 46.78 q/ha. The minimum yield obtained PKV-HMT (33.79 q/ha) with upper and lower limit 45.63 and 21.96 q/ha respectively.*

**Key Words:** Structural time series model, AIC, BIC, Goodness of fit

## *1. INTRODUCTION*

ARIMA time series methodology is widely used for modelling time series data. Statistical modelling of time-series data in Agriculture is usually carried out by employing ARIMA methodology (Brockwell and Davis, 1991).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 fundamental mechanism. An alternative mechanistic approach, which is quite promising, is the "Structural time series modelling (Harvey, 1996)". A quite promising, mechanistic approach, which does not suffer from this drawback, is "Structural time-series modelling (STSM)" (Harvey). The distinguishing feature of this methodology is that observations are regarded as made up of distinct components such as trend and cyclical fluctuations and each of which is modelled separately. The techniques that emerge from this approach are extremely flexible and are capable of handling a much wider range of problems than is possible through ARIMA approach.

The Akaike Information Criterion (AIC) is a measure of the relative quality of statistical models for a given set of data. Given a collection of models for the data, AIC estimates the quality of each model, relative to each of the other models. Hence, AIC provides a means for model selection. BIC is an estimate of a function of the posterior probability of a model being true, under a certain Bayesian setup, so that a lower BIC means that a model is considered to be more likely to be the true model. Once a model is estimated, its suitability can be assessed using goodness fit statistics.

Promising variety is a popular variety and being cultivated widely. It may be a variety, an advance line, strain or land race (recommended or non-recommended). However, variety is a group of plants having distinct, uniform and stable traits which has been recommended for cultivation by a committee. There are many promising varieties of rice, are available but it depends on cultivation practices and geographical areas where some specific varieties are more suitable for its better production.

Rice is an important crop grown in nearly 44 million ha of land in the country with the yield of 2.2 t/ha which is less than the productivity of many countries. Annual population growth rate of the country is nearly 1.8 % and if per capita consumption of rice is expected to be 400 gm of rice per day then the demand for rice in 2025 will be 130 m. tonnes. In Chhattisgarh, rice occupies average of 3.6 million ha. with the yield of the state ranging between 1.2 to 1.6 t/ha depending upon the rainfall (Pandey, 2013). Though the yield of rice in the state is lower-than the national average but high yielding varieties in the state is higher than the state yield as well as national yield which is ranging between 3.9 to 4.9 t/ha.

## 2. MATERIALS AND METHODS

The study mainly confined to secondary collected for a period 2009-10 to 2014-15 data of promising varieties of Rice yield. Data collected from various publications, Government of Chhattisgarh were subjected structural time series model. The data are analyzed by using software Statistical Analysis System (SAS). Structural time series model adopted for forecasting purpose is given below.

### 2.1 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.

$$Y_t = T_t + C_t + S_t + \varepsilon_t \quad (1)$$

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

(i) ***Local Level Model*** *(LLM):* In the absence of seasonal and cyclical components, eq. (1) reduce to

$$Y_t = \mu_t + \varepsilon_t, \qquad \varepsilon_t \sim N(0, \sigma_\varepsilon^2), \qquad t = 1, 2... T \quad (2)$$

Where $\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t$ and $\beta t = \beta_{t-1} + \varepsilon_t$

(ii) ***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).

$$AIC = -2 \log L + 2n, \quad (3)$$

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

$$BIC = -2\log L + n \log T, \quad (4)$$

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

## 3. RESULTS AND DISCUSSION

### 3.1 The yield trends of promising varieties of rice

In, recent years, structural time series model for functional estimation has become increasingly popular as a tool for time series data analysis. As these techniques, it may be mentioned that models are fitted to the data and coefficient parameter value obtained on the basis of the model are compared with the actual observation for assessing the accuracy of the fitted model. Structural trend model is applied to the data sets. Parameters estimated as well as goodness of fit statistics are presented in Table 3.1. Model is fitted to the data sets using Statistical Analysis System (SAS) statistical software package version 9.2.

Structural time series model are developed basically to trends find the forecast the yield. To validate the forecasting ability of the fitted models, for the three years with upper and lower limit. Evidently, initially there was an increase in all Rice promising variety yield in Chhattisgarh. Corresponding trend information of 9 (all varieties describes).

*Table 3.1 Trend information for different promising Rice variety of Chhattisgarh*

| Promising Variety | Intercept | Slope | AIC | BIC |
|---|---|---|---|---|
| Sawarna | 49.81 | 0.16 | 17.39 | 15.55 |
| MTU-1010 | 37.33 | 0.22 | 19.33 | 17.49 |
| MTU-1001 | 45.01 | -0.07 | 18.48 | 16.63 |
| IR-36 | 38.69 | 1.22 | 29.37 | 27.53 |
| IR-64 | 42.84 | 0.36 | 31.09 | 29.25 |
| Mahamaya | 47.38 | 0.35 | 29.59 | 27.75 |
| Karma Masuri | 41.78 | 0.71 | 30.85 | 29.00 |
| Bamleshwari | 42.58 | 0.30 | 25.84 | 24.00 |
| PKV-HMT | 33.55 | 0.07 | 27.07 | 25.23 |
| BPT-5204 | 41.92 | 0.81 | 35.65 | 33.80 |

It could be concluded from the Table 3.2 that the Swarna variety have minimum AIC (17.39) and BIC (15.55) obtained among 9 high yielding varieties followed by MTU-1001 with AIC (18.48) and BIC (16.63) respectively. Thus the data clearly indicated that the maximum yield have Swarna variety. The maximum AIC (35.65) and BIC (33.80) obtained for the variety of BPT-5204.

*Table3.2 Forecast for different promising rice variety (qt/ha) Chhattisgarh*

| | 2015-16 | | 2016-17 | | 2017-18 | |
|---|---|---|---|---|---|---|
| **Variety** | **Forecast** | **Standard Error** | **Forecast** | **Standard Error** | **Forecast** | **Standard Error** |
| Sawarna | 49.98 | 0.90 | 50.14 | 1.37 | 50.31 | 1.80 |
| MTU-1010 | 37.55 | 1.14 | 37.77 | 1.75 | 37.99 | 2.29 |
| MTU-1001 | 44.87 | 0.87 | 44.79 | 0.98 | 44.94 | 1.09 |
| IR-36 | 39.91 | 4.02 | 41.14 | 6.15 | 42.36 | 8.05 |
| IR-64 | 43.21 | 4.99 | 43.58 | 7.62 | 43.94 | 9.98 |
| Mahamaya | 47.73 | 4.13 | 48.09 | 6.32 | 48.44 | 8.27 |
| Karma .Masuri | 42.50 | 4.12 | 43.21 | 4.60 | 43.92 | 5.14 |
| Bamleshwari | 42.89 | 2.20 | 43.20 | 2.464 | 43.51 | 2.75 |
| PKV-HMT | 33.63 | 3.01 | 33.71 | 4.61 | 33.79 | 6.03 |
| BPT-5204 | 42.74 | 7.52 | 43.56 | 8.39 | 44.37 | 9.36 |

The result in Table 3.2 and Table 3.3 found that maximum rice yield forecast for the year 2017-18 about 50.31 q/ha with upper and lower limit 53.84 and 46.78 q/ha followed by yield of Mahamaya variety obtained 48.44 q/ha with upper and lower limit 64.66 and 32.22 q/ha respectively. The minimum yield obtained PKV-HMT (33.79 q/ha) with upper and lower limit 45.63 and 21.96 q/ha respectively. From the Table 3.3 it is observed that the forecasts using Structural time series model shows an increasing trend for promising varieties of rice in Chhattisgarh.

## *4. CONCLUSION*

In our study the structural time-series model developed for Rice yield comparison of the state yield showed that the yield of high yielding / promising varieties are much higher ( 143 %) than the state yield of rice. This indicates that the promotion of high yielding varieties can be made for improving the overall productivity of the state.

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***Table 3.3 Fitting of Structural time series***

| Variety | 2015-16 | | | 2016-17 | | | 2017-18 | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Lower Limit** | **Upper Limit** | **Model Width** | **Lower Limit** | **Upper Limit** | **Model Width** | **Lower Limit** | **Upper Limit** | **Model Width** |
| Sawarna | 48.21 | 51.74 | 3.53 | 47.45 | 52.84 | 5.39 | 46.78 | 53.84 | 7.06 |
| MTU-1010 | 35.30 | 39.80 | 4.50 | 34.33 | 41.20 | 6.87 | 33.49 | 42.49 | 9.00 |
| MTU-1001 | 43.22 | 46.66 | 3.44 | 42.94 | 46.79 | 3.85 | 42.65 | 46.94 | 4.29 |
| IR-36 | 29.08 | 53.20 | 24.12 | 26.57 | 58.15 | 31.58 | 24.38 | 63.51 | 39.13 |
| IR-64 | 33.43 | 52.99 | 19.56 | 28.63 | 58.52 | 29.89 | 24.38 | 63.51 | 39.13 |
| Mahamaya | 39.62 | 55.84 | 16.22 | 35.70 | 60.48 | 24.78 | 32.22 | 64.66 | 32.44 |
| Karma Masuri | 34.41 | 50.59 | 16.18 | 34.18 | 52.24 | 18.06 | 33.85 | 54.00 | 20.15 |
| Bamleshwari | 38.56 | 47.22 | 8.66 | 38.37 | 48.03 | 9.66 | 38.12 | 48.90 | 10.78 |
| PKV-HMT | 27.72 | 39.55 | 11.83 | 24.67 | 42.76 | 18.09 | 21.96 | 45.63 | 23.67 |
| BPT-5204 | 28.00 | 57.48 | 29.48 | 27.11 | 60.00 | 32.89 | 26.01 | 62.73 | 36.72 |
| **Average width** | | | **13.75** | **Average width** | | **18.11** | **Average width** | | **22.24** |