

Test for shift in the production of food grains in India

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ABSTRACT

Empirical analysis of structural change or shift in the production of food grains (rice, wheat, cereals, pulses) of Indian states during the period of sixteen years from 2000-01 to 2015-16 is studied through chow test and dummy variable approach assuming a linear relationship between production of food grains as dependent variable and irrigated area of rice, wheat, cereals, pulses as independent variables. This test for shift in the production of food grains is done within the states of each zone and among the zones during 2000-2016 as well as between the two periods 2000-2008 and 2008-2016 in each zone and India as a whole. For the purpose of this study the relevant data is extracted from the "Hand Book of Statistics on Indian States" published by Reserve Bank of India.

Key words: Empirical analysis, structural change, food grains, irrigated area, linear regression, chow test, dummy variable approach.

Mathematics Subject Classification: 62JXX

1. INTRODUCTION

The aim of present study is to extend the theoretical methodology for testing the shift in the production of food grains among different states of each of the six zones of India and among zones of India during 2000-2016 as well as between two periods 2000-08 and 2008-16 in each zone and India as a whole. Variables Under study are production of rice, wheat, cereals and pulses respectively denoted by P_r , P_w , P_c , P_p in thousand tonnes; Irrigated area of rice, wheat, cereals and pulses respectively denoted by I_r , I_w , I_c , I_p in thousand hectares. The related data is extracted from the Hand book of Statistics on Indian States published by Reserve Bank of India.

India is divided into six zones based on geographical area. Each zone is comprised of a certain number of states and union territories. Following is the order of zones and states considered in view of the analysis of data on production as well as irrigated area of rice, wheat, cereals and pulses in each zone:

- I) North Zone: 1.NCT-Delhi, 2.Haryana, 3. Himachal Pradesh, 4. Jammu & Kashmir, 5. Punjab, 6. Uttar Pradesh, 7.Uttarakhand.
- II) East Zone: 1. Bihar, 2. Jharkhand, 3.Odisha, 4. West Bengal.
- III) West Zone: 1. Goa, 2. Gujarat, 3. Maharashtra, 4. Rajasthan.
- IV) South Zone: 1. Andhra Pradesh, 2. Karnataka, 3.Kerala, 4.Puducherry, 5. Tamil Nadu.
- V) Central Zone: 1. Chhattisgarh, 2. Madhya Pradesh.
- VI) North-East Zone: 1. Arunachal Pradesh, 2. Assam, 3.Manipur, 4. Meghalaya, 5. Mizoram, 6. Nagaland, 7. Sikkim & 8. Tripura.

We assume that total production of food grains is a function of irrigated area of rice, wheat, cereals and pulses. For some states in west zone, south zone and north-east zone the data on wheat is not available.

The model for North, East and Central zones: $Y_1 = \alpha_0 + \alpha_1 I_R + \alpha_2 I_W + \alpha_3 I_C + \alpha_4 I_P + \epsilon_1$ (1)

The model for West, South and North-east zones is $Y_2 = \beta_0 + \beta_1 I_R + \beta_2 I_C + \beta_3 I_P + \epsilon_2$ (2)

Where $Y_1 = P_r + P_w + P_c + P_p$, $Y_2 = P_r + P_c + P_p$, α_i, β_j are parameters, $i = 0, 1, 2, 3, 4$; $j = 0, 1, 2, 3$; ϵ_1, ϵ_2 : error variables.

2. METHODOLOGY

For testing the shift or change in the total production of food grains through the specified models (1) and (2), we apply Chow test and Dummy variable method. Using Chow test, we infer that whether there is a shift or not in the dependent variable. But using dummy variable method, we infer that if there is a shift in the dependent variable, it gives additional information whether the shift is due to intercept or slope coefficients of independent variables. We may construct these two methods for shift in the dependent variable with different number of data sets and different number of independent variables.

When a linear regression model is used to represent a relationship among a specified variables then the question often arises, whether the relationship remains holds for two different groups of data on the same variables or whether the relationship remains stable in two different time periods. These two questions can be given answer by testing whether two sets of observations can be regarded to the same regression model or not through Chow test (1960). This procedure of testing may be conducted for any number of data sets and any number of independent variables in the regression model. Chow test is rather general in nature, it simply tests whether sets of regressions are different or not, without specifying the difference if any, is due to differences in intercept terms or due to differences in slope coefficients. To overcome this ambiguity Damodar Gujarati (Feb 1970, Dec 1970) explained dummy variable method which clearly points out the sources of difference, that is whether the difference is due to the intercept or the slope or both. Chow test is a multistage procedure, whereas from dummy variable method, just with one regression we can obtain the estimates of parameters of all sets of regressions.

Here we present the procedure of Chow test and dummy variable method for testing the shift in the production of food grains involving different number of data sets and different number of independent variables say (2,3),(2,4),(3,3),(3,4),(4,3),(4,4),(5,3),(6,3),(7,4) and (8,3) combinations in the regression model. The first and second numbers of each pair in parenthesis indicates number of data sets and the number of independent variables respectively.

Chow test:

For two data sets and three independent variables, consider

$$Y_i = a_1 + b_1X_{1i} + c_1X_{2i} + d_1X_{3i} + u_{1i} \quad , i = 1, 2, \dots, n_1 \quad (3)$$

$$Y_j = a_2 + b_2X_{1j} + c_2X_{2j} + d_2X_{3j} + u_{2j} \quad , j = 1, 2, \dots, n_2 \quad (4)$$

The subscripts i and j refers to first and second data sets of observations respectively.

To test whether two regressions are different,

(i)Combine all the (n_1+n_2) observations and compute OLS estimates of a, b, c, and d in the combined regression $Y = a + bX_1 + cX_2 + dX_3 + \epsilon$. From this equation obtain the sum of squared residuals (SSR) S_1 with degrees of freedom (n_1+n_2-k) , where $k=4$ (number of parameters). (ii) Estimate equations (3) & (4) separately and obtain respective SSR say S_2 & S_3 with degrees of freedom (n_1-k) and (n_2-k) respectively. Add these two SSR say $S_4 = S_2+S_3$ with degrees of freedom (n_1+n_2-2k) . (iii) Obtain $S_5 = S_1-S_4$ with degrees of freedom k.

$$(iv) \text{ Compute } F = \frac{[S_5]/k}{[S_4]/(n_1+n_2-2k)} \sim F(k, n_1 + n_2 - 2k) \quad (5)$$

If $F_{cal} > F_{cri}$, reject H_0 that the parameters are same.

Now we can extend this procedure for any number of data sets and any number of independent variables.

For three data sets and three independent variables, (i) write three individual regression equations by involving three independent variables corresponding to three data sets with n_1, n_2 and n_3 observations respectively. (ii)Combine all $(n_1+n_2+n_3)$ observations and compute the OLS estimates of k ($=4$) parameters in combined regression $Y = a + bX_1 + cX_2 + dX_3 + \epsilon$. From this equation obtain SSR say S_1 with degrees of freedom $(n_1+n_2+n_3-k)$. (iii)Estimate the three individual regression equations separately and obtain the respective SSR say S_2, S_3, S_4 with degrees of freedom $(n_1-k), (n_2-k)$ and (n_3-k) respectively. Add these three SSR say $S_5 = S_2+S_3+S_4$ with degrees of freedom $(n_1+n_2+n_3-3k)$. (iv)Obtain $S_6 = S_1-S_5$ with degrees of freedom $2k$.

$$(v) \text{ Compute } F = \frac{[S_6]/2k}{[S_5]/(n_1+n_2+n_3-3k)} \sim F(2k, n_1 + n_2 + n_3 - 3k) \quad (6)$$

If $F_{cal} > F_{cri}$, then reject H_0 , otherwise accept H_0 .

For four data sets and three independent variables, (i) write four individual regression equations by involving three independent variables corresponding to four data sets with n_1, n_2, n_3 and n_4 observations respectively. (ii) Combine all $(n_1+n_2+n_3+n_4)$ observations and compute the OLS estimates of k ($=4$) parameters of combined regression $Y = a + bX_1 + cX_2 + dX_3 + \epsilon$. From this equation obtain SSR say S_1 with degrees of freedom $(n_1+n_2+n_3+n_4-k)$. (iii) Estimate four individual regression equations separately and obtain the respective SSR say S_2, S_3, S_4, S_5 with degrees of

freedom (n_1-k) , (n_2-k) , (n_3-k) and (n_4-k) respectively. Add these four SSR say $S_6 = S_2+S_3+S_4+S_5$ with degrees of freedom $(n_1+n_2+n_3+n_4-4k)$. (iv) Obtain $S_7 = S_1-S_6$ with degrees of freedom $3k$. (v) Compute

$$F = \frac{[S_7]/3k}{[S_6]/(n_1+n_2+n_3+n_4-4k)} \sim F(3k, n_1 + n_2 + n_3 + n_4 - 4k) \quad (7)$$

If $F_{cal} > F_{cri}$, then reject H_0 , otherwise accept H_0 .

For five data sets and three independent variables, (i) write five individual regression equations by involving three independent variables corresponding to five data sets with n_1 , n_2 , n_3 , n_4 and n_5 observations respectively. (ii) Combine all $(n_1+n_2+n_3+n_4+n_5)$ observations and compute the OLS estimates of k ($=4$) parameters of combined regression $Y = a + bX_1 + cX_2 + dX_3 + \epsilon$. From this equation obtain SSR say S_1 with degrees of freedom $(n_1+n_2+n_3+n_4+n_5-k)$. (iii) Estimate five individual regression equations separately and obtain the respective SSR say S_2 , S_3 , S_4 , S_5 and S_6 with degrees of freedom (n_1-k) , (n_2-k) , (n_3-k) , (n_4-k) and (n_5-k) respectively. Add these five SSR say $S_7 = S_2+S_3+S_4+S_5+S_6$ with degrees of freedom $(n_1+n_2+n_3+n_4+n_5-5k)$. (iv) Obtain $S_8 = S_1-S_7$ with degrees of freedom $4k$.

$$(v) \text{ Compute } F = \frac{[S_8]/4k}{[S_7]/(n_1+n_2+n_3+n_4+n_5-5k)} \sim F(4k, n_1 + n_2 + n_3 + n_4 + n_5 - 5k) \quad (8)$$

If $F_{cal} > F_{cri}$, then reject H_0 , otherwise accept H_0 .

For six data sets and three independent variables, (i) write six individual regression equations by involving three independent variables corresponding to six data sets with n_1 , n_2 , n_3 , n_4 , n_5 and n_6 observations respectively. (ii) Combine all $(n_1+n_2+n_3+n_4+n_5+n_6)$ observations and compute the OLS estimates of k ($=4$) parameters of combined regression $Y = a + bX_1 + cX_2 + dX_3 + \epsilon$. From this equation obtain SSR say S_1 with degrees of freedom $(n_1+n_2+n_3+n_4+n_5+n_6-k)$. (iii) Estimate six individual regression equations separately and obtain the respective SSR say S_2 , S_3 , S_4 , S_5 , S_6 and S_7 with degrees of freedom (n_1-k) , (n_2-k) , (n_3-k) , (n_4-k) , (n_5-k) and (n_6-k) respectively. Add these six SSR say $S_8 = S_2+S_3+S_4+S_5+S_6+S_7$ with degrees of freedom $(n_1+n_2+n_3+n_4+n_5+n_6-6k)$. (iv) Obtain $S_9 = S_1-S_8$ with degrees of freedom $5k$. (v) Compute,

$$F = \frac{[S_9]/5k}{[S_8]/(n_1+n_2+n_3+n_4+n_5+n_6-6k)} \sim F(5k, n_1 + n_2 + n_3 + n_4 + n_5 + n_6 - 6k) \quad (9)$$

If $F_{cal} > F_{cri}$, then reject H_0 , otherwise accept H_0 .

For seven data sets and four independent variables, (i) write seven individual regression equations by involving four independent variables corresponding to seven data sets with n_1 , n_2 , n_3 , n_4 , n_5 , n_6 and n_7 observations respectively. (ii) Combine all $(n_1+n_2+n_3+n_4+n_5+n_6+n_7)$ observations and compute the OLS estimates of k ($=5$) parameters of combined regression $Y = a + bX_1 + cX_2 + dX_3 + eX_4 + \epsilon$. From this equation obtain the SSR say S_1 with degrees of freedom $(n_1+n_2+n_3+n_4+n_5+n_6+n_7-k)$. (iii) Estimate seven individual regression equations separately and obtain the respective SSR say S_2 , S_3 , S_4 , S_5 , S_6 , S_7 and S_8 with degrees of freedom (n_1-k) , (n_2-k) , (n_3-k) , (n_4-k) , (n_5-k) , (n_6-k) and (n_7-k) respectively. Add these SSR say $S_9 = S_2+S_3+S_4+S_5+S_6+S_7+S_8$ with degrees of freedom $(n_1+n_2+n_3+n_4+n_5+n_6+n_7-7k)$. (iv) Obtain $S_{10} = S_1-S_9$ with degrees of freedom $6k$. (v) Compute

$$F = \frac{[S_{10}]/6k}{[S_9]/(n_1+n_2+n_3+n_4+n_5+n_6+n_7-7k)} \sim F(6k, n_1 + n_2 + n_3 + n_4 + n_5 + n_6 + n_7 - 7k) \quad (10)$$

If $F_{cal} > F_{cri}$, then reject H_0 , otherwise accept H_0 .

For eight sets of data and three independent variables, (i) write eight individual regression equations by involving three independent variables corresponding to eight data sets with $n_1, n_2, n_3, n_4, n_5, n_6, n_7$ and n_8 observations respectively. (ii) Combine all $(n_1+n_2+n_3+n_4+n_5+n_6+n_7+n_8)$ observations and compute the OLS estimates of $k (=4)$ parameters of combined regression $Y = a + bX_1 + cX_2 + dX_3 + \epsilon$. From this equation obtain the SSR say S_1 with degrees of freedom $(n_1+n_2+n_3+n_4+n_5+n_6+n_7+n_8-k)$. (iii) Estimate eight individual regression equations separately and obtain the respective SSR say $S_2, S_3, S_4, S_5, S_6, S_7, S_8$ and S_9 with degrees of freedom $(n_1-k), (n_2-k), (n_3-k), (n_4-k), (n_5-k), (n_6-k), (n_7-k)$ and (n_8-k) respectively. Add these eight SSR say $S_{10} = S_2+S_3+S_4+S_5+S_6+S_7+S_8+S_9$ with degrees of freedom $(n_1+n_2+n_3+n_4+n_5+n_6+n_7+n_8-8k)$.

(iv) Obtain $S_{11} = S_1 - S_{10}$ with degrees of freedom $7k$. (v) Compute $F = \frac{[S_{11}]/7k}{[S_{10}]/(n_1+n_2+n_3+n_4+n_5+n_6+n_7+n_8-8k)} \sim F(7k, n_1 + n_2 + n_3 + n_4 + n_5 + n_6 + n_7 + n_8 - 8k) \quad (11)$

If $F_{cal} > F_{cri}$, then reject H_0 , otherwise accept H_0 .

Dummy variable method:

For two data sets and three independent variables X_1, X_2, X_3 to test the equality of two regressions, we write the regression equation with one dummy variable D as follows:

$$Y_j = \beta_0 + \beta_1 D + \beta_2 X_{1j} + \beta_3 D X_{1j} + \beta_4 X_{2j} + \beta_5 D X_{2j} + \beta_6 X_{3j} + \beta_7 D X_{3j} + \epsilon_j, j=1,2,\dots, (n_1+n_2) \quad (12)$$

n_1, n_2 are number of observations in first and second data sets.

$D = 1$, if the observation lies in the second set of data

$= 0$, otherwise (in the first set of data)

β_0 = intercept for first data set

β_1 = differential intercept for second data set

$\beta_2, \beta_4, \beta_6$: Slope coefficients of Y with respect to X_1, X_2 , and X_3 respectively for first data set.

$\beta_3, \beta_5, \beta_7$: differential slope coefficients of Y with respect to X_1, X_2 , and X_3 respectively for second data set.

For three data sets and three independent variables, to test the equality of three individual regressions we write the equation with two dummy variables D_1 and D_2 as follows:

$$Y_j = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 X_{1j} + \beta_4 D_1 X_{1j} + \beta_5 D_2 X_{1j} + \beta_6 X_{2j} + \beta_7 D_1 X_{2j} + \beta_8 D_2 X_{2j} + \beta_9 X_{3j} + \beta_{10} D_1 X_{3j} + \beta_{11} D_2 X_{3j} + \epsilon_j, j = 1, 2, 3, \dots, (n_1+n_2+n_3) \dots \quad (13)$$

$D_1 = 1$, if the observation lies in II set;

$D_2 = 1$, if the observation lies in III set

$= 0$, otherwise

$= 0$, otherwise

β_0 : intercept for first data set

β_1, β_2 : differential intercepts for II and III sets respectively

$\beta_3, \beta_6, \beta_9$: slope coefficients of Y with respect to X_1, X_2, X_3 respectively for I set

$\beta_4, \beta_7, \beta_{10}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for II set

$\beta_5, \beta_8, \beta_{11}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for III set

Depending on the statistical significance of estimated differential intercepts and differential slope coefficients, one can find out whether the three individual regressions are same or not.

For four data sets and three independent variables, to test the equality of four individual regressions we write the equation with three dummy variables D_1, D_2 and D_3 as follows:

$$Y_j = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 X_{1j} + \beta_5 D_1 X_{1j} + \beta_6 D_2 X_{1j} + \beta_7 D_3 X_{1j} + \beta_8 X_{2j} + \beta_9 D_1 X_{2j} + \beta_{10} D_2 X_{2j} + \beta_{11} D_3 X_{2j} + \beta_{12} X_{3j} + \beta_{13} D_1 X_{3j} + \beta_{14} D_2 X_{3j} + \beta_{15} D_3 X_{3j} + \epsilon_j, j=1,2,3,\dots,(n_1+n_2+n_3+n_4) \quad (14)$$

$D_1 = 1$, if the observation lies in II set;

= 0, otherwise

$D_3 = 1$, if the observation lies in IV set

= 0, otherwise

$D_2 = 1$, if the observation lies in III set;

= 0, otherwise

β_0 : intercept for I set

$\beta_1, \beta_2, \beta_3$: differential intercepts for II, III and IV sets respectively

$\beta_4, \beta_8, \beta_{12}$: slope coefficients of Y with respect to X_1, X_2, X_3 respectively for I set

$\beta_5, \beta_9, \beta_{13}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for II set

$\beta_6, \beta_{10}, \beta_{14}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for III set

$\beta_7, \beta_{11}, \beta_{15}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for IV set

Depending on the statistical significance of estimated differential intercepts and differential slope coefficients, one can find out whether the four individual regressions are same or not.

For five data sets and three independent variables, to test the equality of four individual regressions we write the equation with four dummy variables D_1, D_2, D_3 and D_4 as follows:

$$Y_j = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 X_{1j} + \beta_6 D_1 X_{1j} + \beta_7 D_2 X_{1j} + \beta_8 D_3 X_{1j} + \beta_9 D_4 X_{1j} + \beta_{10} X_{2j} + \beta_{11} D_1 X_{2j} + \beta_{12} D_2 X_{2j} + \beta_{13} D_3 X_{2j} + \beta_{14} D_4 X_{2j} + \beta_{15} X_{3j} + \beta_{16} D_1 X_{3j} + \beta_{17} D_2 X_{3j} + \beta_{18} D_3 X_{3j} + \beta_{19} D_4 X_{3j} + \epsilon_j, j = 1, 2, 3, \dots, (n_1+n_2+n_3+n_4+n_5) \quad (15)$$

$D_1 = 1$, if the observation lies in II set;

= 0, otherwise

$D_3 = 1$, if the observation lies in IV set

= 0, otherwise

$D_2 = 1$, if the observation lies in III set;

= 0, otherwise

$D_4 = 1$, if the observation lies in V set

= 0, otherwise

β_0 : intercept for I set

$\beta_1, \beta_2, \beta_3, \beta_4$: differential intercepts for II, III, IV and V sets respectively

$\beta_5, \beta_{10}, \beta_{15}$: slope coefficients of Y with respect to X_1, X_2, X_3 respectively for I set

$\beta_6, \beta_{11}, \beta_{16}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for II set

$\beta_7, \beta_{12}, \beta_{17}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for III set

$\beta_8, \beta_{13}, \beta_{18}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for IV set

$\beta_9, \beta_{14}, \beta_{19}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for V set

Depending on the statistical significance of estimated differential intercepts and differential slope coefficients, one can find out whether the five individual regressions are same or not.

For six data sets and three independent variables, to test the equality of six individual regressions we write the equation with five dummy variables D_1, D_2, D_3, D_4 and D_5 as follows:

$$Y_j = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 X_{1j} + \beta_7 D_1 X_{1j} + \beta_8 D_2 X_{1j} + \beta_9 D_3 X_{1j} + \beta_{10} D_4 X_{1j} + \beta_{11} D_5 X_{1j} + \beta_{12} X_{2j} + \beta_{13} D_1 X_{2j} + \beta_{14} D_2 X_{2j} + \beta_{15} D_3 X_{2j} + \beta_{16} D_4 X_{2j} + \beta_{17} D_5 X_{2j} + \beta_{18} X_{3j} + \beta_{19} D_1 X_{3j} + \beta_{20} D_2 X_{3j} + \beta_{21} D_3 X_{3j} + \beta_{22} D_4 X_{3j} + \beta_{23} D_5 X_{3j} + \epsilon_j, j=1,2,\dots,(n_1+n_2+n_3+n_4+n_5+n_6) \quad (16)$$

$D_1 = 1$, if the observation lies in II set;

$= 0$, otherwise

$D_2 = 1$, if the observation lies in III set;

$= 0$, otherwise

$D_3 = 1$, if the observation lies in IV set;

$= 0$, otherwise

β_0 : intercept for I set

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$: differential intercepts for II, III, IV, V and VI sets respectively.

$\beta_6, \beta_{12}, \beta_{18}$: slope coefficients of Y with respect to X_1, X_2, X_3 respectively for I set

$\beta_7, \beta_{13}, \beta_{19}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for II set

$\beta_8, \beta_{14}, \beta_{20}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for III set

$\beta_9, \beta_{15}, \beta_{21}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for IV set

$\beta_{10}, \beta_{16}, \beta_{22}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for V set

$\beta_{11}, \beta_{17}, \beta_{23}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for VI set

Depending on the statistical significance of estimated differential intercepts and differential slope coefficients, one can find out whether the six individual regressions are same or not.

For seven data sets and four independent variables, to test the equality of seven individual regressions we write the equation with six dummy variables D_1, D_2, D_3, D_4, D_5 and D_6 as follows:

$$Y_j = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 D_6 + \beta_7 X_{1j} + \beta_8 D_1 X_{1j} + \beta_9 D_2 X_{1j} + \beta_{10} D_3 X_{1j} + \beta_{11} D_4 X_{1j} + \beta_{12} D_5 X_{1j} + \beta_{13} D_6 X_{1j} + \beta_{14} X_{2j} + \beta_{15} D_1 X_{2j} + \beta_{16} D_2 X_{2j} + \beta_{17} D_3 X_{2j} + \beta_{18} D_4 X_{2j} + \beta_{19} D_5 X_{2j} + \beta_{20} D_6 X_{2j} + \beta_{21} X_{3j} + \beta_{22} D_1 X_{3j} + \beta_{23} D_2 X_{3j} + \beta_{24} D_3 X_{3j} + \beta_{25} D_4 X_{3j} + \beta_{26} D_5 X_{3j} + \beta_{27} D_6 X_{3j} + \beta_{28} X_{4j} + \beta_{29} D_1 X_{4j} + \beta_{30} D_2 X_{4j} + \beta_{31} D_3 X_{4j} + \beta_{32} D_4 X_{4j} + \beta_{33} D_5 X_{4j} + \beta_{34} D_6 X_{4j} + \epsilon_j, j=1,2,3,\dots,(n_1+n_2+n_3+n_4+n_5+n_6+n_7) \quad (17)$$

$D_1 = 1$, if the observation lies in II set;

$= 0$, otherwise

$D_2 = 1$, if the observation lies in III set;

$= 0$, otherwise

$D_3 = 1$, if the observation lies in IV set;

$= 0$, otherwise

β_0 : intercept for first data set

$D_4 = 1$, if the observation lies in V set

$= 0$, otherwise

$D_5 = 1$, if the observation lies in VI set

$= 0$, otherwise

$D_6 = 1$, if the observation lies in VII set

$= 0$, otherwise

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$: differential intercepts for II, III, IV, V, VI and VII sets respectively.

$\beta_7, \beta_{14}, \beta_{21}, \beta_{28}$: slope coefficients of Y with respect to X_1, X_2, X_3, X_4 respectively for I set

$\beta_8, \beta_{15}, \beta_{22}, \beta_{29}$: differential slope coefficients of Y with respect to X_1, X_2, X_3, X_4 respectively for II set

$\beta_9, \beta_{16}, \beta_{23}, \beta_{30}$: differential slope coefficients of Y with respect to X_1, X_2, X_3, X_4 respectively for III set

$\beta_{10}, \beta_{17}, \beta_{24}, \beta_{31}$: differential slope coefficients of Y with respect to X_1, X_2, X_3, X_4 respectively for IV set

$\beta_{11}, \beta_{18}, \beta_{25}, \beta_{32}$: differential slope coefficients of Y with respect to X_1, X_2, X_3, X_4 respectively for V set

$\beta_{12}, \beta_{19}, \beta_{26}, \beta_{33}$: differential slope coefficients of Y with respect to X_1, X_2, X_3, X_4 respectively for VI set

$\beta_{13}, \beta_{20}, \beta_{27}, \beta_{34}$: differential slope coefficients of Y with respect to X_1, X_2, X_3, X_4 respectively for VII set

Depending on the statistical significance of estimated differential intercepts and differential slope coefficients, one can find out whether the seven individual regressions are same or not.

For eight data sets and three independent variables, to test the equality of eight individual regressions we write the equation with seven dummy variables $D_1, D_2, D_3, D_4, D_5, D_6$ and D_7 as follows:

$$Y_j = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 D_6 + \beta_7 D_7 + \beta_8 X_{1j} + \beta_9 D_1 X_{1j} + \beta_{10} D_2 X_{1j} + \beta_{11} D_3 X_{1j} + \beta_{12} D_4 X_{1j} + \beta_{13} D_5 X_{1j} + \beta_{14} D_6 X_{1j} + \beta_{15} D_7 X_{1j} + \beta_{16} X_{2j} + \beta_{17} D_1 X_{2j} + \beta_{18} D_2 X_{2j} + \beta_{19} D_3 X_{2j} + \beta_{20} D_4 X_{2j} + \beta_{21} D_5 X_{2j} + \beta_{22} D_6 X_{2j} + \beta_{23} D_7 X_{2j} + \beta_{24} X_{3j} + \beta_{25} D_1 X_{3j} + \beta_{26} D_2 X_{3j} + \beta_{27} D_3 X_{3j} + \beta_{28} D_4 X_{3j} + \beta_{29} D_5 X_{3j} + \beta_{30} D_6 X_{3j} + \beta_{31} D_7 X_{3j} + \epsilon_j, j = 1, 2, 3, \dots, (n_1 + n_2 + n_3 + n_4 + n_5 + n_6 + n_7 + n_8) \quad (18)$$

$D_1 = 1$, if the observation lies in II set;

$= 0$, otherwise

$D_2 = 1$, if the observation lies in III set;

$= 0$, otherwise

$D_3 = 1$, if the observation lies in IV set;

$= 0$, otherwise

$D_4 = 1$, if the observation lies in V set;

$= 0$, otherwise

$D_5 = 1$, if the observation lies in VI set

$= 0$, otherwise

$D_6 = 1$, if the observation lies in VII set

$= 0$, otherwise

$D_7 = 1$, if the observation lies in VIII set

$= 0$, otherwise

β_0 : intercept for I set

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$: differential intercepts for II, III, IV, V, VI, VII and VIII sets respectively.

$\beta_8, \beta_{16}, \beta_{24}$: slope coefficients of Y with respect to X_1, X_2, X_3 for I set

$\beta_9, \beta_{17}, \beta_{25}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for II set

$\beta_{10}, \beta_{18}, \beta_{26}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for III set

$\beta_{11}, \beta_{19}, \beta_{27}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for IV set

$\beta_{12}, \beta_{20}, \beta_{28}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for V set

$\beta_{13}, \beta_{21}, \beta_{29}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for VI set

$\beta_{14}, \beta_{22}, \beta_{30}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for VII set

$\beta_{15}, \beta_{23}, \beta_{31}$: differential slope coefficients of Y with respect to X_1, X_2, X_3 respectively for VIII set

Depending on the statistical significance of estimated differential intercepts and differential slope coefficients, one can find out whether the eight individual regressions are same or not.

3. EMPIRICAL STUDY

In this section we are testing for the shift in the production of total food grains(Y) among different states in (i) central, (ii) north, (iii) east zones which contains respectively two, seven, four states with four independent variables I_r , I_w , I_c , I_p ; and in (iv) west, (v) south, (vi) north east zones which contains respectively four, five, eight states with three independent variables I_r , I_c , I_p ; (vii) among six zones (north, east, central, west, south, north east) with three independent variables I_r , I_c , I_p ; (viii) among three zones (west, south, north east) with three independent variables I_r , I_c , I_p ; (ix) among three zones (north, east, central) with four independent variables I_r , I_w , I_c , I_p ; Also to test the shift between two periods 2000-01 to 2007-08 and 2008-09 to 2015-16 in (x) central, (xi) north, (xii) east zones with four independent variables I_r , I_w , I_c , I_p ; (xiii) west, (xiv) south, (xv) north east zones with three independent variables; (xvi) India as a whole with three independent variables I_r , I_c , I_p ;

For computational point of view the data on related variables is considered in following formats for all the above sixteen cases. For cases (i) – (vi) we consider the time series data pertaining to the period 2000-01 to 2015-16 respectively as 32, 112, 64, 64, 80, 128 observations such that sixteen observations for each state on related variables in the order given in each zone. For the cases (vii) – (ix) we consider the sum of observations of each related variable of all states in each year for each zone, such that each zone has sixteen observations. Hence for case (vii) we have $16 \times 6 = 96$ observations, similarly for the cases (viii) & (ix) we have 48 observations each. For the cases (x)-(xv) we have sixteen observations for each zone during 2000-01 to 2015-16 on related variables as we considered in cases (vii)-(ix). For the case (xvi) we have sixteen observations such that, we club all the six zones data for each year on related variables. Numerical results are computed with the help of Excel, SPSS using Chow's method & dummy variable method and presented in tables (1)-(14), conclusions are drawn accordingly. For this purpose appropriate procedures are adopted from the methodology. Also it is to be noted that $X_1 = I_r$, $X_2 = I_w$, $X_3 = I_c$, $X_4 = I_p$.

Table 1				
H ₀ : There is no significant difference in the production of food grains between two states of Central Zone .				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variable	Coefficient	p-value
S ₁ = 36044345	27	Constant	-32238.99	0.11914
S ₂ = 5526861.1	11	D	5734.96	0.78258
S ₃ = 11170705	11	X ₁	8.73	0.10596
S ₄ = 16697566	22	DX ₁	-3.47	0.54966
S ₅ = 19346779	5	X ₂	24.47	0.44285
n ₁ = 16		DX ₂	-18.86	0.55344
n ₂ = 16		X ₃	-13.59	0.00798
K = 5		DX ₃	15.42	0.00468
F _{cal} = 5.098098		X ₄	8.19	0.01999
F _{cri} = 2.6612739		DX ₄	-6.83	0.05986

From table (1), according to Chow's method, since $F_{cal} > F_{cri}$, we reject H_0 and conclude that there is significant difference in production of food grains between two states of Central zone. According to Dummy variable method, since the differential coefficient of X_3 is significant we say that there is significant difference in production of food grains between Chhattisgarh and Madhya Pradesh with respect to irrigated area of Cereals (X_3).

Table 2				
H ₀ : There is no significant difference in the production of food grains among seven states of North Zone.				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variable	Coefficient	p-value
S ₁ = 243132912	107	Constant	12	0.998
S ₂ = 711.86142	11	D1	-31114	0.098
S ₃ = 5118128.9	11	D2	-449	0.976
S ₄ = 265007.16	11	D3	-7850	0.798
S ₅ = 337448.13	11	D4	-58962	0.245
S ₆ = 7251969	11	D5	-61997	0.003
S ₇ = 117053189	11	D6	2175	0.806
S ₈ = 72411.839	11	X1	12	0.985
S ₉ = 130098866	77	D1X1	-14	0.983
S ₁₀ = 113034045	30	D2X1	-88	0.897
n ₁ = 16		D3X1	9	0.989
n ₂ = 16		D4X1	-12	0.986
n ₃ = 16		D5X1	-5	0.994
n ₄ = 16		D6X1	-11	0.986
n ₅ = 16		X2	1.7	0.985
n ₆ = 16		D1X2	17.1	0.852
n ₇ = 16		D2X2	9	0.930
K = 5		D3X2	-4.8	0.959
F _{cal} = 2.2300019		D4X2	23.7	0.797
F _{cri} = 1.6072683		D5X2	5.5	0.952
		D6X2	-1.6	0.987
		X3	-0	0.999
		D1X3	-2	0.988
		D2X3	13	0.919
		D3X3	12	0.928
		D4X3	-23	0.862
		D5X3	-3	0.979
		D6X3	-1	0.993
		X4	-19	0.993
		D1X4	44	0.984
		D2X4	7	0.998
		D3X4	38	0.987
		D4X4	43	0.985
		D5X4	22	0.992
		D6X4	15	0.995

From table (2), according to Chow's method, since $F_{cal} > F_{cri}$, we conclude that there is significant difference in the production of food grains among seven states of North zone. According to Dummy variable method, since the differential intercept D_5 is significant we say that there is a significant difference in the production of food grains with respect to intercept term of the model of Uttar Pradesh state.

Table 3				
H ₀ : There is no significant difference in the production of food grains among four states of East zone .				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
$S_1 = 192424149.3$	59	(Constant)	-66118.181	.000
$S_2 = 16667222.41$	11	D1	63525.108	.000
$S_3 = 1140592.067$	11	D2	50714.447	.007
$S_4 = 5712546.913$	11	D3	65728.313	.000
$S_5 = 2542401.316$	11	X1	4.631	.000
$S_6 = 26062762.71$	44	D1X1	-2.611	.088
$S_7 = 166361386.6$	15	D2X1	-1.225	.574
$n_1 = 16$		D3X1	-2.134	.148
$n_2 = 16$		X2	14.510	.001
$n_3 = 16$		D1X2	-3.982	.745
$n_4 = 16$		D2X2	-318.589	.056
$K = 5$		D3X2	-16.948	.202
$F_{cal} = 18.72377867$		X3	49.098	.000
$F_{cri} = 1.900235579$		D1X3	-44.493	.007
		D2X3	-37.472	.035
		D3X3	-28.366	.128
		X4	-3.548	.559
		D1X4	5.567	.446
		D2X4	12.668	.058
		D3X4	8.460	.418

From table (3), according to Chow's method, since $F_{cal} > F_{cri}$, we conclude that there is significant difference in the production of food grains in the four states of east zone. According to Dummy variable method, since the differential intercepts D_1 , D_2 , D_3 and differential slope coefficients D_1X_3 and D_2X_3 are significant we say that there is significant difference in the production of food grains in the intercepts of models Jharkhand, Odisha, West Bengal and in the slope coefficient of irrigated area of cereals in the models of Jharkhand and Odisha.

Table 4				
H ₀ : There is no significant difference in the production of food grains among four states of West zone.				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
S ₁ = 72851857.92	60	Constant	101.71162	0.98885
S ₂ = 2234.337031	12	D1	1963.9843	0.79588
S ₃ = 3315594.813	12	D2	-11859.945	0.53830
S ₄ = 16149345.36	12	D3	-3535.7691	0.65395
S ₅ = 37852043.18	12	X1	0.2072136	0.99909
S ₆ = 57319217.69	48	D1X1	1.1412303	0.99503
S ₇ = 15532640.24	12	D2X1	7.9629471	0.96537
n ₁ = 16		D3X1	-1.1739229	0.99489
n ₂ = 16		X3	38.29091	0.98898
n ₃ = 16		D1X3	-38.762231	0.98885
n ₄ = 16		D2X3	-38.371394	0.98896
K = 4		D3X3	-38.009711	0.98906
F _{cal} = 1.083939444		X4	1.5725325	0.99224
F _{cri} = 1.96012106		D1X4	0.523913	0.99742
		D2X4	1.324982	0.99346
		D3X4	1.1577984	0.99429

From table (4), according to Chow's method, Since $F_{cal} < F_{cri}$, we accept H_0 and conclude that there is no significant difference in the production of food grains in the four states of west zone. According to Dummy variable method, since none of the differential intercepts and differential slope coefficients is significant we conclude that there is no significant difference in the production of food grains in the four states of West zone.

Table 5				
H ₀ : There is no significant difference in the production of food grains among five states of South Zone.				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
S ₁ = 97200446.01	76	Constant	112.992	.937
S ₂ = 18315318.92	12	D1	-13139.205	.045
S ₃ = 21419935	12	D2	102.466	.962
S ₄ = 8795.371618	12	D3	-88.728	.976
S ₅ = 143.904093	12	D4	-2241.737	.535
S ₆ = 12761034.69	12	X1	4.196	.000
S ₇ = 52505227.89	60	D1X1	4.815	.017
S ₈ = 44695218.12	16	D2X1	-2.633	.742
n ₁ = 16		D3X1	-2.782	.986
n ₂ = 16		D4X1	-1.302	.362
n ₃ = 16		X3	-2.077	.126
n ₄ = 16		D1X3	3.114	.130
n ₅ = 16		D2X3	-9.658	.955
K = 4		D3X3	20.528	.996
F _{cal} = 3.192197704		D4X3	-2.513	.458
F _{cri} = 1.81511336		X4	1.506	.295
		D1X4	1.834	.300
		D2X4	3.179	.975
		D3X4	-1.923	.993
		D4X4	10.648	.000

From table (5), according to Chow's method, Since $F_{cal} > F_{cri}$, we conclude that there is significant difference in the production of food grains in the five states of south zone. According to Dummy variable method, since the differential intercept D_1 and differential slope coefficients D_1X_1 and D_4X_4 are significant, we conclude that there is significant difference in the intercept and slope coefficient of irrigated area of rice of the model Karnataka and slope coefficient of irrigated area of pulses of the model Tamil Nadu.

Table 6				
H ₀ : There is no significant difference in the production of food grains among eight states of North East Zone.				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
$S_1 = 5252623.4$	124	Constant	-350	0.768
$S_2 = 20978.654$	12	D1	-5628	0
$S_3 = 708970.7$	12	D2	483	0.687
$S_4 = 58844.317$	12	D3	-1483	0.405
$S_5 = 3146.1326$	12	D4	373	0.755
$S_6 = 14011.124$	12	D5	-138	0.91
$S_7 = 41971.237$	12	D6	382	0.793
$S_8 = 79.716022$	12	D7	144	0.924
$S_9 = 17809.969$	12	X1	1.8	0.861
$S_{10} = 865811.85$	96	D1X1	0.5	0.965
$S_{11} = 4386811.5$	28	D2X1	-0.1	0.99
$n_1 = 16$		D3X1	3.9	0.786
$n_2 = 16$		D4X1	0.1	0.992
$n_3 = 16$		D5X1	3.3	0.756
$n_4 = 16$		D6X1	-3.8	0.838
$n_5 = 16$		D7X1	1.7	0.878
$n_6 = 16$		X3	4.3	0.776
$n_7 = 16$		D1X3	-11.4	0.536
$n_8 = 16$		D2X3	-2.2	0.899
$K = 4$		D3X3	69.2	0.277
$F_{cal} = 17.371553$		D4X3	-3.1	0.903
$F_{cri} = 1.5936766$		D5X3	-3.6	0.818
		D6X3	-2.6	0.907
		D7X3	46.9	0.243
		X4	14.8	0.731
		D1X4	25.5	0.555
		D2X4	-16.4	0.707
		D3X4	-13.7	0.777
		D4X4	-23.6	0.665
		D5X4	-13.7	0.757
		D6X4	-13.3	0.762
		D7X4	-34.5	0.468

From table (6), according to Chow's method, since $F_{cal} > F_{cri}$, we conclude that there is significant difference in the production of food grains in the North east zone. According to Dummy variable method, since the differential intercept D_1 is significant we conclude that there is significant difference in the intercept of the model of Assam.

Table 7				
H_0 : There is no significant difference in the production of food grains among Six Zones of India .				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
$S_1 = 3397394844$	92	Constant	-16044.356	.358
$S_2 = 24183825.49$	12	D1	-37582.210	.096
$S_3 = 44505795.82$	12	D2	8737.598	.640
$S_4 = 59094358.92$	12	D3	-8161.299	.664
$S_5 = 84755425.3$	12	D4	-14885.831	.495
$S_6 = 13634035$	12	D5	7244.638	.765
$S_7 = 531801.2393$	12	X1	5.260	.000
$S_8 = 226705241.8$	72	D1X1	-2.948	.034
$S_9 = 3170689602$	20	D2X1	-3.174	.229
$n_1 = 16$		D3X1	.167	.898
$n_2 = 16$		D4X1	-.429	.875
$n_3 = 16$		D5X1	-2.363	.616
$n_4 = 16$		X3	-1.459	.503
$n_5 = 16$		D1X3	44.400	.003
$n_6 = 16$		D2X3	1.407	.525
$K = 4$		D3X3	1.655	.474
$F_{cal} = 50.34944264$		D4X3	.885	.785
$F_{cri} = 1.718060627$		D5X3	3.383	.936
		X4	1.471	.574
		D1X4	-1.330	.866
		D2X4	1.793	.511
		D3X4	2.153	.450
		D4X4	2.043	.476
		D5X4	23.179	.541

From table (7), according to Chow's method, Since $F_{cal} > F_{cri}$, we conclude that there is significant difference in the production of food grains among six zones of India. According to Dummy variable method, since the differential slope coefficients D_1X_1 and D_1X_3 are significant we conclude that, there is significant difference in the East zone with respect to the irrigated area of rice and cereals.

Table 8				
H ₀ : There is no significant difference in the production of food grains among West, South, North east zones of India.				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
S ₁ = 246103492.1	44	Intercept	-7307.146309	0.37303
S ₂ = 59094358.92	12	D1	30313.70008	0.00987
S ₃ = 84755425.3	12	D2	-1493.609706	0.94578
S ₄ = 531801.2393	12	X1	2.086111994	0.46189
S ₅ = 144381585.5	36	D1X1	2.675844013	0.35723
S ₆ = 101721906.7	8	D2X1	0.811525694	0.89551
n ₁ = 16		X3	-0.052366752	0.90871
n ₂ = 16		D1X3	-4.706350147	0.00031
n ₃ = 16		D2X3	1.977122139	0.96909
K = 4		X4	3.264576416	0.00111
F _{cal} = 3.170408321		D1X4	-2.447682821	0.15987
F _{cri} = 2.208518074		D2X4	21.38869923	0.63911

From table (8), according to Chow's method, since $F_{cal} > F_{cri}$, we conclude that there is significant difference in the production of food grains among West, South, North east zones. According to Dummy variable method, since the differential intercept D₁ and differential slope coefficient D₁X₃ are significant, we conclude that there is significant difference in the intercept term and slope coefficient of irrigated area of cereals of the model of South zone.

Table 9				
H ₀ : There is no significant difference in the production of food grains among North, East, Central zones of India.				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
S ₁ = 713860533	43	Intercept	-192448.8446	0.0058509
S ₂ = 241355580	12	D1	87198.98076	0.2458116
S ₃ = 24694527.1	12	D2	149607.4413	0.0479032
S ₄ = 13595215.2	12	X1	4.884597321	0.0792503
S ₅ = 279645322	33	D1X1	-3.013038524	0.3143501
S ₆ = 434215211	10	D2X1	0.269052465	0.9703606
n ₁ = 16		X2	12.65895705	0.0028888
n ₂ = 16		D1X2	12.09918976	0.3094556
n ₃ = 16		D2X2	-6.82100593	0.2105943
K = 5		X3	7.29698296	0.1559243
F _{cal} = 5.12402706		D1X3	42.48400515	0.0992031
F _{cri} = 2.13250375		D2X3	-7.395779366	0.2912128
		X4	-1.088162855	0.8139232
		D1X4	-3.168133562	0.8188343
		D2X4	3.186877207	0.5826592

From table (9), according to Chow's method, since $F_{cal} > F_{cri}$, we reject H₀ and conclude that there is significant difference in the production of food grains among North, East, Central zones. According to Dummy variable method, since the differential intercept D₂ is significant we conclude that there is significant difference in the intercept term of the model of Central zone.

Table 10				
Ho: There is no significant difference in the production of food grains between two periods 2000-08 & 2008-16 in Central zone .				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
$S_1 = 13595215$	11	Intercept	-103664.93	0.0263123
$S_2 = 4274577.8$	3	D	56003.619	0.230629
$S_3 = 2924128.014$	3	X1	19.598932	0.045308
$S_4 = 7198705.808$	6	DX1	-15.079205	0.1251531
$S_5 = 6396509.416$	5	X2	7.4999891	0.0240685
$n_1 = 8$		DX2	-1.2294427	0.7290538
$n_2 = 8$		X3	-9.3904336	0.0820077
$K = 5$		DX3	12.446523	0.110184
$F_{cal} = 1.066276565$		X4	1.9461852	0.346155
$F_{cri} = 4.387374187$		DX4	0.099679	0.9800837

From table (10), according to Chow's method as well as Dummy variable method there is no significant difference in the production of food grains between the two periods 2000-08 and 2008-16 in central zone.

Table 11				
Ho: There is no significant difference in the production of food grains between two periods 2000-08 & 2008-16 in North zone .				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
$S_1 = 240879372$	11	Intercept	2428.8228	0.996275
$S_2 = 3365933.85$	3	D	551506.81	0.455847
$S_3 = 121201308$	3	X1	6.311984	0.4934381
$S_4 = 124567242.2$	6	DX1	14.048706	0.3084646
$S_5 = 116312129.6$	5	X2	1.5329067	0.9660684
$n_1 = 8$		DX2	-43.324609	0.3794633
$n_2 = 8$		X3	4.743435	0.7112318
$K = 5$		DX3	-26.408067	0.3520087
$F_{cal} = 1.120475601$		X4	-8.1280407	0.5745052
$F_{cri} = 4.387374187$		DX4	49.308925	0.1123252

From table (11), according to both the methods, there is no significant difference in the production of food grains between the two periods 2000-08 and 2008-16 in North zone.

Table 12				
Ho: There is no significant difference in the production of food grains between two periods 2000-08 & 2008-16 in East zone .				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
$S_1 = 24694527$	11	Intercept	-95410.95	0.0109706
$S_2 = 1596967.6$	3	D	-19944.923	0.5877541
$S_3 = 8875875.7$	3	X1	6.9176145	0.0587427
$S_4 = 10472843$	6	DX1	-5.2463258	0.138849
$S_5 = 14221683.71$	5	X2	-2.0226098	0.8865219
$n_1 = 8$		DX2	35.008965	0.0755002
$n_2 = 8$		X3	26.663347	0.2359553
$K = 5$		DX3	36.600446	0.2050095
$F_{cal} = 1.6295499$		X4	0.3494825	0.9707553
$F_{cri} = 4.3873742$		DX4	-16.81833	0.2544486

From table (12), according to both the methods, there is no significant difference in the production of food grains between the two periods 2000-08 and 2008-16 in East zone.

Table 13				
H ₀ : There is no significant difference in the production of food grains between two periods 2000-08 &2008-16 in West zone .				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
S ₁ = 88437174	12	Intercept	-14515.424	0.383626
S ₂ = 9770892.4	4	D	-57363.91	0.2506423
S ₃ = 29565625	4	X1	-4.0200486	0.3993286
S ₄ = 39336517	8	DX1	33.831215	0.094356
S ₅ = 49100657	4	X3	-0.0441385	0.97228
n ₁ = 8		DX3	1.2090479	0.4603729
n ₂ = 8		X4	5.907986	0.0213428
K = 4		DX4	-5.1846576	0.0799641
F _{cal} = 2.4964415				
F _{cri} = 3.8378534				

From table (13), according to both the methods, there is no significant difference in the production of food grains between the two periods 2000-08 and 2008-16 in West zone.

Table 14				
H ₀ : There is no significant difference in the production of food grains between two periods 2000-08 & 2008-16 in South zone .				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
S ₁ = 84755425.3	12	Intercept	-58286.4781	0.082508
S ₂ =30228940.37	4	D	84240.82284	0.0825849
S ₃ =5047396.995	4	X1	5.680972413	0.0001715
S ₄ =35276337.36	8	DX1	-0.73626283	0.6685104
S ₅ =49479087.94	4	X3	3.806836258	0.2131604
n ₁ = 8		DX3	-9.22348624	0.079443
n ₂ = 8		X4	5.899271582	0.1360534
K = 4		DX4	-5.12168396	0.2376468
F _{cal} =2.805228187				
F _{cri} = 3.8378533				

From table (14), we observed that in both the methods there is no significant difference in the production of food grains between the two periods 2000-08 and 2008-16 in central zone.

Table 15				
H ₀ : There is no significant difference in the production of food grains between two periods 2000-08 & 2008-16 in North east zone .				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
S ₁ = 502407.77	12	Intercept	-1581.6674	0.75199
S ₂ = 26736.069	4	D	-683.16716	0.91118
S ₃ = 161272.5	4	X1	1.9740548	0.09373
S ₄ = 188008.57	8	DX1	-1.3389237	0.45688
S ₅ = 314399.2	4	X3	-2.5799075	0.77523
n ₁ = 8		DX3	16.965844	0.29870
n ₂ = 8		X4	7.4318645	0.41763
K = 4		DX4	7.8501743	0.52361
F _{cal} = 3.3445199				
F _{cri} = 3.8378533				

From table (15), we observed that in both the methods there is no significant difference in the production of food grains between the two periods 2000-08 and 2008-16 in north east zone.

Table 16				
H ₀ : There is no significant difference in the production of food grains between two periods 2000-08 & 2008-16 in India as a whole .				
Chow's Method		Dummy Variable Method		
SSR	d.f	Variables	Coefficients	p-value
S ₁ = 403426608.6	12	Intercept	6712.7346	0.9357782
S ₂ = 33870719.84	4	D	-269012.88	0.0807202
S ₃ = 146199750.8	4	X1	5.938245	0.0078075
S ₄ = 180070470.7	8	DX1	-2.3434201	0.3604954
S ₅ = 223356137.9	4	X3	0.0121711	0.9947582
n ₁ = 8		DX3	-3.1681566	0.1754186
n ₂ = 8		X4	6.3574583	0.0028588
K = 4		DX4	-3.1962498	0.1654502
F _{cal} =2.480763638				
F _{cri} = 3.8378534				

From table (16), according to Chow's method, since $F_{cal} < F_{cri}$, and according to Dummy variable method we conclude that there is no significant difference in the production of food grains between the two periods 2000-08 and 2008-16 in India.

4. CONCLUSION

In this study we are testing the shift in the production of food grains between different states of each of the six zones and within zones of India with four independent variables irrigated area of rice, wheat, cereals and pulses. For the purpose of analysis appropriate models are adopted depending upon the availability of data on independent variables.

Following are the observations through empirical study. It is observed that (i) in Central zone, there is significant difference between Chhattisgarh and Madhya Pradesh with respect to irrigated area of cereals. (ii) In North zone, there is significant difference in the intercept term of the model of Uttar Pradesh state. (iii) In East zone, there is significant difference in the intercepts of the models of Jharkhand, Odisha, and West Bengal and in the slope coefficients of irrigated area of cereals in the models of Jharkhand and Odisha. (iv) There is no significant difference among the four states of West zone. (v) In South zone, there is significant difference in the intercept and slope coefficient of irrigated area of rice of the model Karnataka and slope coefficient of irrigated area of pulses of the model Tamil Nadu. (vi) In the Northeast zone, there is significant difference in the intercept term of model of Assam. (vii) Regarding India, there is significant difference in east zone with respect to irrigated areas of rice and cereals. (viii) Among West, South and North east zones of India, there is significant difference in the intercept term and slope coefficient of irrigated area of cereals of the model of South zone. (ix) Among North, East and Central zones of India, there is significant difference in the intercept term of the model of Central zone. (x) There is no significant difference in the production of food grains between two periods 2000-08 and 2008-16 in central, north, east, west, south and northeast zones of India.

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