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R-Software for the Assessment of Structural Changes in Fisheries Production of Andhra Pradesh and Tamil Nadu for Indian GDP

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Abstract

A Chow test was applied to analyze the structural changes in GDP of India with respect to Fisheries GDP obtained from the states of Andhra Pradesh and Tamil Nadu using Unrestricted and Restricted Linear Regression models in matrix notation for the period of 2000–01 to 2013–14. The GDP and Fisheries GDP data pertaining to the state of Andhra Pradesh and Tamil Nadu for the periods 2000–01 to 2006–07 and 2007–08 to 2013–14 were also collected for analyzing the structural changes between earmarked two periods as well as states from 2000–01 to 2013–14. In this study, the Chow test revealed that there was no structural change between the total GDP of India and Fisheries GDP with respect to the states Andhra Pradesh and Tamil Nadu during the periods 2001–2007 and 2008 –2014. However, significant structural changes could be observed between the GDP of India and Fisheries GDP obtained from the states of Andhra Pradesh and Tamil Nadu during the period 2000–2001 to 2013–14.However, there was a positive trend of structural change observed in the states Andhra Pradesh and Tamil Nadu with respect to the GDP of India and Fisheries GDP during the period 2000–2001 to 2012–14. Owing to theses, it is concluded that the contribution of fisheries with respect to the country's GDP between the periods made a significant structural change however no many structural changes were observed in two time periods within the states.

Keywords: Chow test, fisheries GDP, R–coding, restricted, unrestricted, regression

1. Introduction

In India, the fisheries sector occupies a very important place in the socio–economic development of the country holding the third position in fisheries production and second in aquaculture contributing 5.43% of global fish production. The contributing 1.07% to the national GDP and 5.30% to the agriculture GDP (Soibam et al., 2020). The contribution of aquaculture and fisheries production to Gross Domestic Product (GDP) is also considered as one of the most important indicators for assessing the economic performance of the country. Though strong attention and great efforts are being attempted for assessing the contribution of aquaculture and fisheries to the GDP of the country, lack of understanding and poor measures to assess the sector's contribution to GDP hinder the process of making evidence based policy and planning towards sustainable aquaculture and fisheries development. However, the Government of India has recently included fisheries GDP as one of the measures in its

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2030 Agenda to achieve its Sustainable Development Goals (SDGs). The share of agriculture and allied activities in the total GDP is constantly declining from 34.69% in 1980–81 to 17.62% in 2004–05 (Ganesh et al., 2010) whereas, the share of the fisheries sector in the total GDP (at current prices) increased from 0.40% in 1950–51 to 1.03% in 2017–18, accounting an increase of 157%. The fisheries sector contributed Rs. 1, 75,573 crores to the Indian GDP (at current prices) during FY 2017–18 (Anonymous, 2020; Srinath, 2003; Boopendranath, 2007; Rajani, 2021). The fish production has increased from 0.75 mt in 1950 to 6.87 mt in 2008, a more than nine fold increase. At the same time the share of inland fisheries has gone up from 29% to over 50% with production of over 3.3 million tonnes occupying the second position in the world and the contribution of aquaculture to the GDP is 1.07% (Goswami et al., 2012; Rohit et al., 2017). Andhra Pradesh and Telangana state among 647 fisher households comprising five major sectors viz., brackish water, freshwater, reservoir and marine fisheries as well as procurement and marketing sectors to understand the level of socio–economic development of fishers (Ponnusamy et al., 2016). The agriculture sector is also known as the primary sector contributing 13.7 per–cent of GDP (Madhusudhan, 2015). The long–term co–integrated relationship between national income and fishery consumption in a panel of 101 countries for the period 1970–2006 were worked out (Chyi–Lu etal., 2014). Agriculture shares 19.95% of gross domestic product of the country and 62% people directly involved with agriculture (Al–Mamun et al., 2013). The fisheries sector has been exhibiting steady growth in the total Gross Value Added and records about 6.58% share of Agricultural GDP which increased robustly. The share of fisheries, in fact, is elevating the agricultural growth upward for the past few decades (Vasisht et al., 2009). Raise of Coastal aquaculture farming in India during the 1990s attributes the increase in country's GDP through exports and acquiring foreign exchange and also growth performance of Indian fish and fishery exports products (Krishnan et al., 2002; Radhakrishnan et al., 2018). In India, the sector has been one of the major contributors in earning foreign exchange being one of the leading seafood exporting nations in the world. In the year 2017–18, the marine exports accounted for 5% of the total exports of India and constituted 19.23 % of Agri–exports. Nevertheless, the export of marine products increased to 13, 92, 559 mt worth Rs. 46,589 crores during the year 2018–19. As the fisheries production plays a major role in shifting the country's GDP, it is essential to study the shift or change in the country's domestic production with respect to fisheries and aquaculture indicating the economic status of the nation. Fish production from inland and marine waters started declining due to proliferation of water control, habitat degradation and indiscriminate fishing (Pradeep et al., 2005) which cause fluctuation in fish production and changes structure of fisheries GDP (Ganesh et al., 2010). In recent years, Chow test is one of the important method nowadays used to study the structural change in two-time series data of various kinds (Rajani et al., 2021). Further, various researches have been undertaken to study the two sets of observations with three independent variables, three sets of observations with two independent variables, three sets of observations with four independent variables applying the Chow test for studying the structural change. The purpose of this study was to infer through the Chow test whether GPD is homogeneously dependent on the independent factor viz., fisheries over the years using Unrestricted and Restricted Linear Regression model in matrix notation for assessing the structural changes in GDP of the country.

2. Materials and Methods

The present study was conducted using fisheries the data of Andhra Pradesh and Tamil Nadu separately for structural changes between the two periods 2000–01 to 2006–07 and 2007–08 to 2013–14, also between two states Andhra Pradesh and Tamil Nadu during 2000–01 to 2013–14. In this study, data on fisheries GDP was chosen only upto 2013–14 since the fisheries GDP was calculated based on capture fisheries only upto 2013–14. From later year onwards, the fisheries GDP is being calculated taking both capture and culture fisheries production. Hence, this analysis was conducted for a time series data of 14 years from 2000–2001 to 2013–2014 collecting the data from the Directorate of Economics and Statistics(Anonymous, 2015a) and Ministry of Statistics and Programme Implementation(Anonymous, 2015b), Government of India.

2.1. Chow test for structural changes in two time series data

If there were two regressions, representing observations in two states for a cross section study in two different periods for time series study, it might be questioned whether the behavior of two states or in the two different time periods differs by testing the null hypothesis as;

H_0: $\beta_1 = \beta_2$ i.e., there is no structural change in two states (or) in two time periods.

Considering two general linear regression models in matrix notation for two samples of n_1 and n_2 observations respectively as

$$Y_1 = X_1 \beta_1 + \epsilon_1 \quad (1)$$

$$Y_2 = X_2 \beta_2 + \epsilon_2 \quad (2)$$

where Y_1 is $(n_1 \times 1)$, Y_2 is $(n_2 \times 1)$;

X_1 is $(n_1 \times k)$, X_2 is $(n_2 \times k)$;

β_1 is $(k \times 1)$, β_2 is $(k \times 1)$ matrices.

k is number of sets.

(i) *Unrestricted Linear Regression model in matrix notation*

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}_{(n_1+n_2)\times 1} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix}_{(n_1+n_2)\times 2k} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix}_{(2k\times 1)} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \end{bmatrix}_{(n_1+n_2)\times 1} \quad ....3$$

$$\Rightarrow Y = X\beta + \epsilon$$

Here, $Y=\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}_{(n_1+n_2)\times 1}$, $X=\begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix}_{(n_1+n_2)\times 2k}$

$\begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix}_{(2k\times 1)} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \end{bmatrix}_{(n_1+n_2)\times 1}$

By applying the least squares estimation method, one might estimate the unrestricted linear regression model (3) and obtain the unrestricted least squares residual sum of squares in matrix notation as (ϵ'ϵ).

(ii) *Restricted Linear Regression model under H_0: $\beta_1 = \beta_2$ in matrix notation*

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}_{(n_1+n_2)\times 1} = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix}_{(n_1+n_2)\times k} \beta_1 (k\times 1) + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \end{bmatrix}_{(n_1+n_2)\times 1} \quad ....4$$

$Y=X\beta+\epsilon$

Here, $Y=\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}_{(n_1+n_2)\times 1}$, $X=\begin{bmatrix} X_1 \\ X_2 \end{bmatrix}_{(n_1+n_2)\times k}$, $\epsilon\begin{bmatrix} \epsilon_1 \\ \epsilon_2 \end{bmatrix}_{(n_1+n_2)\times 1}$

Again, applying the least squares estimation method to estimate restricted linear regression model (4), one might obtain the restricted least squares residual sum of squares in matrix notation as (ϵ'ϵ).

Now, the chow test statistic for testing the structural change under H_0 is given as

$$F=\frac{\left[\left(\varepsilon'\varepsilon\right)_R-\left(\varepsilon'\varepsilon\right)_{UR}\right]/k}{\left(\varepsilon'\varepsilon\right)_{UR}/\left(n_1+n_2\right)-2k} \sim F_{[k,(n_1+n_2)-2k]} \quad ....5$$

Hence, one might compare the calculated value of the F–test statistic with its critical value for (k, (n_1 + n_2 – 2k)) degrees of freedom at an appropriate level of significance and draw the inference accordingly.

3. Results and Discussion

The structural changes were analysed using Chow test statistics for GDP in two aspects viz., (i) in two selected periods of 2000–2001 to 2006–2007 and 2007–2008 to 2013–14 for both the states of Andhra Pradesh and Tamil Nadu, (ii) in two selected states of Andhra Pradesh and Tamil Nadu during the period 2000–2001 to 2013–14 employing R – Software version (4.0.2). The impact of Agricultural inputs on Agricultural Gross Domestic Product in Indian Economy using a simple regression analysis for the period 1980–1981 to 2015–2016.Thestudy reveals that the variables like fertilizers and net irrigated area are not statistically significant, which means they do not have a significant impact on agricultural GDP during the time period 1980–1981 to 2015–2016 (Reddy et al., 2018).

The maximum total GDP and Fishery GDP in India was observed in the year 2013–14 over the 14 years followed by 2012–13 and 2011–12 respectively (Figure 1). There is an improvement in the fisher's education, training, diversification of economic activities, employment, savings pattern and consumption expenditure over time. The increase in the

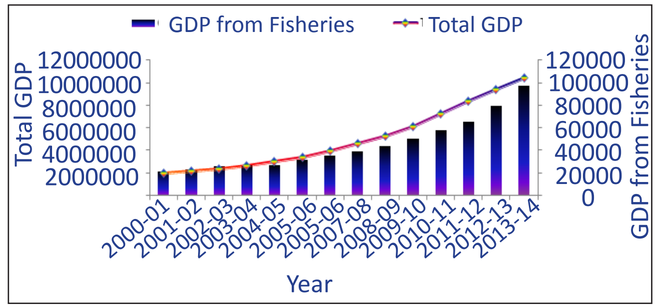

Figure 1: Total GDP and fishery GDP in India

percentage of fishers involved in subsidiary activity tells that they were not receiving the fruit of increasing fisheries GDP. In the year 2017–18, the marine exports accounted for 5% of the total exports of India and constituted 19.23 % of Agri–exports. Nevertheless, the export of marine products increased to 13, 92, 559 metric tons worth Rs.46, 589 crore during the year 2018–19 (Pradeep et al., 2005). In India, fisheries sector contributes substantially to foreign exchange earnings through seafood exports and about 910 million of the population is projected to include fish in their diet by 2020 (Rao et al., 2011).

In Tamil Nadu, The maximum total GDP was observed in the year 2013–14 over the 14 years followed by 2012–13 and 2011–12 respectively. In case of Andhra Pradesh, highest GDP was observed in the year 2013-14 followed by 2009-10 and 2012-13 respectively. In the same way, the maximum Fishery GDP in Tamil Nadu was observed in the year 2012–13 followed by 2013–14and 2011–12 respectively. In case of Andhra Pradesh, maximum GDP was observed in the year 2013–14 over the 14 years followed by 2012–13 and 2011–12 respectively (Figure 2). The declining trend in marine fisheries especially the states from Tamil Nadu and Andhra Pradesh due to indiscriminate fishing of juveniles on a large scale and lack

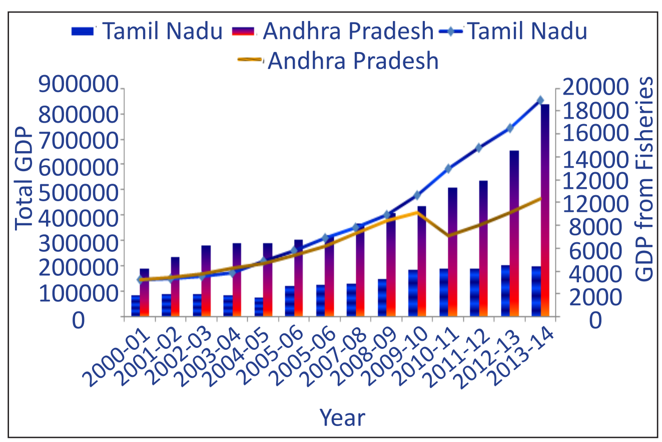

Figure 2: Total GDP and fishery GDP in Tamil Nadu and Andhra Pradesh

of control measures in regulating the fishery. Productions from both inland and marine resources were in progress till 2004 in both states and later started fluctuating which might be the reason for insignificant changes in the structure of fisheries GDP between the two periods studied (Ganesh et al., 2010).

3.1. Analysis of structural changes in two time periods 2000–01 to 2006–07 and 2007–08 to2013–14.

For Andhra Pradesh

(i) Unrestricted Linear Regression model

On calculating the Unrestricted Linear Regression equation by using matrix algebra in R–Software, the results obtained for the state fisheries production from the state of Andhra Pradesh with National GDP in two time periods are;

$$X_1^T X_1 = \begin{bmatrix} 26363636 & 0 \\ 0 & 1066300085 \end{bmatrix}, \quad X_1^T Y = \begin{bmatrix} 8658798307 \\ 32549266660 \end{bmatrix}$$

$$\beta = \left[\left(X_1^T X_1 \right)^{-1} \left(X_1^T Y \right) \right] = \begin{bmatrix} 32.84372 \\ 30.52543 \end{bmatrix} = \begin{bmatrix} Intercept \\ Slope \end{bmatrix}$$

Hence the regression equation obtained is $Y_i = f(X_i) = 32.84372+30.5243X_i$

Therefore unrestricted linear regression model is Y= Xβ+ϵ

Now obtained the unrestricted least squares residual sum of squares in matrix notation as(ϵ'ϵ) is47578842036.

Therefore $(\epsilon'\epsilon)_{UR}$= 47578842036, k= 2

(ii) Restricted Linear Regression model under H_0: $\beta_1 = \beta_2$ in matrix notation

On calculating the Restricted Linear Regression equation by using matrix algebra in R –Software, the results obtained for the state fisheries production from the state of Andhra Pradesh with National GDP in two time periods are;

$$X_1^T X_1 = \begin{bmatrix} 14 & 125598 \\ 125598 & 1329936446 \end{bmatrix}, \quad X_1^T Y = \begin{bmatrix} 4058921 \\ 41208064957 \end{bmatrix}$$

$$\beta = \left[\left(X_1^T X_1 \right)^{-1} \left(X_1^T Y \right) \right] = \begin{bmatrix} 78212.61110 \\ 23.59866 \end{bmatrix} = \begin{bmatrix} Intercept \\ Slope \end{bmatrix}$$

Hence the regression equation is $Y_i = f(X_i) = 78212.61110 + 23.59866X_i$

Therefore restricted linear regression model is Y=Xβ+ϵ

Now obtained the restricted least squares residual sum of squares in matrix notation as (ϵ'ϵ) is 34200180643.

Therefore $(\epsilon'\epsilon)_R$= 34200180643, k= 2

Now, the chow test statistic for testing the structural change in two time periods under H_0 is given by

$$F = \frac{\left[(34200180643)_R - (47578842036)_{UR} \right] / 2}{(47578842036)_{UR} / (7+7) - 2(2)} \sim F_{[2,(7+7)-2(2)]}$$

F =1.4059.

Therefore the calculated F value is 1.4059. And the F critical value with (2, 10) degrees of freedom at 5% level of significance is 4.103.

As the calculated F value is less than the critical F value (1.4059 < 4.103), the null hypothesis is accepted that there was no structural change in fisheries GDP obtained between two time periods 2001–2007 and 2008–2014 in Andhra Pradesh.

For Tamil Nadu

(i) Unrestricted Linear Regression model

On calculating the Unrestricted Linear Regression equation by using matrix algebra in R –Software, the results obtained for the state fisheries production from the state of Tamil Nadu with National GDP in two time periods are;

$$X_1^T X_1 = \begin{bmatrix} 32894228 & 0 \\ 0 & 111010858 \end{bmatrix}, \quad X_1^T Y = \begin{bmatrix} 9314761667 \\ 16681395745 \end{bmatrix}$$

$$\beta = \left[\left(X_1^T X_1 \right)^{-1} \left(X_1^T Y \right) \right] = \begin{bmatrix} 95.68903 \\ 150.26815 \end{bmatrix} = \begin{bmatrix} Intercept \\ Slope \end{bmatrix}$$

Hence the regression equation is $Y_i = f(X_i) = 95.68903+150.26815X_i$

Therefore unrestricted linear regression model is Y= Xβ+ϵ

Now obtained the unrestricted least squares residual sum of squares in matrix notation as (ϵ'ϵ) is186713898568.

Therefore $(\epsilon'\epsilon)_{UR}$= 186713898568, k= 2

(ii) Restricted Linear Regression model under H_0:β_1=β_2 in matrix notation

Calculating the Restricted Linear Regression equation by using matrix algebra in R –Software, the results obtained for the state fisheries production from the state of Tamil Nadu with National GDP in two time periods are;

$$X_1^T Y = \begin{bmatrix} 5499628 \\ 19829012412 \end{bmatrix}, \quad X_1^T X_1 = \begin{bmatrix} 14 & 42500 \\ 42500 & 14390586 \end{bmatrix}$$

$$\beta = \left[\left(X_1^T X_1 \right)^{-1} \left(X_1^T Y \right) \right] = \begin{bmatrix} -246177.3861 \\ 210.4967 \end{bmatrix} = \begin{bmatrix} Intercept \\ Slope \end{bmatrix}$$

Hence the regression equation is $Y_i = f(X_i) = -246177.3861 + 210.4967X_i$

Therefore restricted linear regression model is Y= Xβ+ϵ

Now obtained the restricted least squares residual sum of squares in matrix notation as (ϵ'ϵ) is 76372454527.

Therefore $(\epsilon'\epsilon)_R$= 76372454527, k= 2

Now, the chow test statistic for testing the structural change in two time periods under H_0 is given by

$$F = \frac{\left[(76372454527)_R - (186713898568)_{UR} \right] / 2}{(186713898568)_{UR} / (7+7) - 2(2)} \sim F_{[2,(7+7)-2(2)]}$$

F = 2.9548

Therefore the Calculated F value is 2.9548 while the ‘F’ critical value with (2, 10) degrees of freedom at 5% level of significance is 4.103.

Since the calculated ‘F’ value is less than the Critical ‘F’ value

(2.9548<4.103), the null hypothesis is accepted that there was no structural change in fisheries GDP between two time periods 2001–2007 and 2008–2014 in Tamil Nadu.

As the null hypothesis is accepted between time periods in both the states Andhra Pradesh and Tamil Nadu, it is understood that there was no structural change in fisheries GDP obtained during these two time periods.

3.2. Analysis of structural change between two states Andhra Pradesh and Tamil Nadu

(i) Unrestricted linear regression model

Calculating the Unrestricted Linear Regression equation by using matrix algebra in R–Software, the results obtained for the two states fisheries production from the time period 2000–01 to 2013–14 with national GDP are;

$$X_1^T X_1 = \begin{bmatrix} 1329936446 & 0 \\ 0 & 143905086 \end{bmatrix}, X_1^T Y = \begin{bmatrix} 412208064967 \\ 19829012412 \end{bmatrix}$$

$$\beta = \left[\left(X_1^T X_1 \right)^{-1} \left(X_1^T Y \right) \right] = \begin{bmatrix} 30.98499 \\ 137.79230 \end{bmatrix} = \begin{bmatrix} Intercept \\ Slope \end{bmatrix}$$

Hence the regression equation $f(X_i)$ =30.98499+137.79230X_i

Therefore unrestricted linear regression model is Y=Xβ+ϵ

Now obtained the unrestricted least squares residual sum of squares in matrix notation as (ϵ'ϵ) is 928770779055.

Therefore $(\epsilon'\epsilon)_{UR}$= 928770779055, k= 2

(ii) Restricted Linear Regression model under H_0: $\beta_1 = \beta_2$ in matrix notation

Calculating the Restricted Linear Regression equation by using matrix algebra in R–Software, the results obtained for the two states fisheries production from the time period 2000–01 to 2013–14 with national GDP are;

$$X_1^T X_1 = \begin{bmatrix} 28 & 168098 \\ 168098 & 1473841532 \end{bmatrix}, X_1^T Y = \begin{bmatrix} 9558549 \\ 6103707379 \end{bmatrix}$$

$$\beta = \left[\left(X_1^T X_1 \right)^{-1} \left(X_1^T Y \right) \right] = \begin{bmatrix} 294188.5000 \\ 7.8601 \end{bmatrix} = \begin{bmatrix} Intercept \\ Slope \end{bmatrix}$$

Hence the regression equationis $f(X_i)$ = 294188.5+ 7.8601X_i

Therefore restricted linear regression model is Y= Xβ+ϵ

Now obtained the restricted least squares residual sum of squares of in matrix notation as (ϵ'ϵ) is 982770055779

Therefore $(\epsilon'\epsilon)_R$= ,k= 2

Now, the Chow test statistic for testing the structural change in two states under H_0 is given by

$$F = \frac{\left[(982770055779)_R - (928770779055)_{UR} \right] / 2}{(928770779055)_{UR} / \left((14+14) - 2(2) \right)} \sim F_{\left[2, (14+14) - 2(2) \right]}$$

Therefore the calculated F value is 6.9769. And the critical 'F' value at (2, 24) degrees of freedom at a 5% level of significance is 4.260.

As the calculated 'F' value is greater than the critical 'F' value (6.9769>4.260),the null hypothesis is rejected that there is a structural change in fisheries GDP between the states of Andhra Pradesh and Tamil Nadu during the period 2000–2001 to 2013–2014. In the last 25 years, the contribution of the fisheries sector to the Gross Domestic Product (GDP) is continued to grow at a rapid rate unlike agriculture because of the expansion of the culture fisheries enterprise (Ganesh et al., 2010).The share of the fisheries sub–sector in the agricultural gross domestic product (AGDP) has gradually increased during the last few decades. An increase in GDP in recent years has occurred due to the transformation of the sector from traditional activity into a significant commercial enterprise through coastal aqua farming which promotes the growth and development in the fisheries sector (Sathiadhas et al., 2014; Suresh et al., 2018).

4. Conclusion

The chow test was applied to the fisheries production data related to Andhra Pradesh and Tamil Nadu states during the periods 2000–2001 to 2013–2014 for testing the structural changes with respect to the GDP of India. The analysis indicated that no structural change–that could be observed in the total GDP of India and Fisheries GDP during the time periods 2001–2007 and 2008–2014 with respect to the states of Andhra Pradesh and Tamil Nadu.

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