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Research Paper

Structural Stability of Regression Model: India's Agricultural Production in the Pre-Liberalization and Post Liberalization Periods

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Abstract
The structural stability of the regression model for agricultural production – foodgrains and major commercial crops, as well as the area under cultivation of foodgrains and commercial crops during the Pre-Liberalization (Period I) and Post-Liberalization (Period II) periods was assessed using secondary data obtained from the Ministry of Agriculture & Farmers Welfare, Government of India, and the Reserve Bank of India's Manual of Statistics on the Indian Economy.There is no structural stability in the agricultural output of foodgrains – rice and total cereals, according to the data; structural stability in wheat, coarse cereals, pulses, and total food grains. The output of the key commercial crops, groundnut, rapeseed, and mustard, differs between the two periods; however, in the soyabean, there is no structural difference. Total oilseed structural stability was observed in both times. Coffee, cotton (Lint), raw jute and mesta, as well as tobacco, have seen structural changes over the two-time period.
Keyword: *Structural stability, Regression,Liberalization, Food grains, Commercial crop*

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I. Introduction

Agriculture is a significant part of the Indian economy, accounting for over 17% of total GDP and employing more than 60% of the population. For around 58 percent of India's population, agriculture is their primary source of income. India is the world's greatest producer of milk, pulses, and jute, and ranks second in rice, wheat, sugarcane, groundnut, vegetables, fruit, and cotton production. Over the last few decades, India's agriculture has grown at a rapid pace. India is the world's second-largest producer of agricultural products.Agriculture and associated sectors account for 20.19 percent of GDP on a sector-by-sector basis. The key variables responsible for the tremendous boost in food grain output were better irrigation systems, pre-monsoon rainfall, and the introduction of new technology. The study "Trends of Area, Production, and Productivity of Food Grain in the North Eastern States of India" by Sharma, A. (2013) found positive trends in food grain production and yield in the North Eastern states; change in production is the result of increased area.The impact of globalisation on the area, production, and productivity of food grains in India was investigated in a paper by V.K. Mishra (2016). indicated that the post-reform period had a negative influence on India's food grain acreage, output, and productivity. Because the area under which food grains are grown has shrunk, so has the amount of food grains produced."Trends in India's Agricultural Growth and its Determinants," by Elumalai Kannan (0000). According to the research period of 1967-68 to 2007-08, India's cropping pattern has changed considerably over time, with a clear shift from the cultivation of foodgrains to commercial crops. Cultivation of coarse cereals dropped by 13.3% throughout the study period. The output and area of pulses did not perform well during this time period. Increased crop productivity was aided by modern seed varieties, fertilizers, irrigation systems, and other factors. Due to technological and institutional support, some rice and wheat production and area are taking place in specific places."Agricultural Productivity Trends in India: Sustainability Issues," Praduman Kumar and Surabhi Mittal (2006). The long-term viability of crop yield is becoming increasingly crucial. The post-green revolution period is marked by high input utilization and a decreasing increase in total factor productivity. In the 1990s, agricultural productivity could not be sustained at the same level as it had been in the 1980s. An rise in agricultural R&D spending, which enhances overall factor production. All kinds of efforts to combat poverty result in an increase in total factor output. In conclusion, agricultural research and development is given top priority in the Indian economy.In India, the cropping pattern moved from the production of food grains to the cultivation of commercial crops, according to Sulochna Meena (2016) "Analysis of growth trends in Indian agricultural sector." Food grain output increased as a result of the adoption of high-quality seeds, bigger fertilizer doses, plant protection agents, and irrigation systems. Good planning and investment were required to bring the agricultural sector's productivity up to speed. Agricultural policy must be implemented properly. The economy will suffer if seasons and types of output are not changed. Investment, mechanization, irrigation facilities, seeds, and price policies should all be properly evaluated and implemented."Trends of Area, Production, and Productivity of Food Grain in the North Eastern States of India," according to A. Sharma (2013). The study's findings revealed good developments in food grain output and yield in the North Eastern states. The study also discovered that changes in production are caused by an increase in area, as well as a combination of the area effect, yield effect, and their interaction.Long-term time series data are required for the structural stability regression model to estimate the change in agricultural production due to changes in the area of production between the two periods. The regression model is estimated and used for prediction assuming that the parameters remain constant across the entire period is suspected, hence more than one regression model is required to see whether there is any change owing to structural changes in the data. As a result, one regression model for period I and the other for period II can be fitted.

Objective

To examine the structural stability of Agricultural Production – food grains and non-food grains in the Pre-liberalization and the Post liberalization periods.

Hypothesis

There is no structural change in the Agricultural production – food grains and non-food grains in the Pre-liberalization and the Post liberalization Periods.

II. Methodology

Secondary data was used to achieve the goals of structural stability in India's agricultural production – food grains and commercial grains. The Ministry of Agriculture & Farmers Welfare, Government of India, Coffee Board of India, Tea Board of India, Reserve Bank of India- Manual of statistics on the Indian Economy – 2020-21 provided the data on the area and production of agricultural output. Pre-Liberalization (Period I – 1970-71 to 1990-91) and Post-Liberalization (Period II – 1991-92 to 2019-2020) of India were covered by the data. The auto correlation of the time series data was calculated to ensure stationary. Both periods were combined (pooled) and then calculated separately for periods I and II. For the structural stability of the regression model, two regression models were generated for comparing two periods in order to determine how agriculture production of food grain and commercial crops behaves in connection to the area under cultivation. The level significance at 5% for the decision-making process.

Structural stability regression model: The Chou test (Gregory Chou test)

$$Y_t = Z_1 + Z_2X_t + E_t$$

In the pooled sample, Y represents the amount of food grains produced (in lakh tonnes), t represents the time period, Z_1 represents the intercept, Z_2 represents the growth parameter to be estimated, X represents the area under cultivation of food grains, and E represents the stochastic term.

$$Y_t = V_1 + V_2X_t + E_t$$

Where Y represents the amount of food grains produced in the I period (in lakh tonnes), t represents the time period, V_1 represents the intercept, V_2 represents the growth parameter to be estimated, X represents the area under cultivation of food grains in the I period, and E represents the stochastic term in the I period; in the sample.

$$Y_t = U_1 + U_2X_t + E_t$$

Where Y represents the amount of food grains produced in the period II (in lakh tonnes), t represents the time period, V_1 represents the intercept, V_2 represents the growth parameter to be estimated, X represents the area under cultivation of food grains in the second period, and E represents the stochastic term in the second period; in the sample. S_1 is the pooled sample's residual sum of squares(RSS_1), S_2 is the I period's residual sum of squares (RSS_2), S_3 is the II period's residual sum of squares (RSS_3), and S_4 is the sum of S_2 and S_3. The difference between S_1 and S_4 is S_5, and the number of parameters is k.

$$F = S_5 / k / S_{4/} (n_1 + n_2 - 2k)$$

Analysis of the Data

Structural Stability of Regression Model for the Agricultural Production – foodgrains and major commercial crops were examined in the Pre-Liberalization and Post Liberalization Periods by table 1 to table 5.

Table 1
Structural Stability of Regression Model – Food grains -Cereals

	Pooled sample	Period I	Period II
Rice	$\hat{Y}_t = 353.21 + 0.0865X_t$ $r^2 = 0.7919$ $S_1 = 5229.524$ D f = 48	$\hat{Y}_t = - 1840.59 + 5.9642X_t$ $r^2 = 0.8372$ $S_2 = 39137.94$ D f = 19	$\hat{Y}_t = -1545.38 + 5.718X_t$ $r^2 = 0.21785$ $S_3 = 359787.9$ D f = 27
	$S_4 = 398925.84$	$S_5 = -393896.316$ F = -22.42	Table value = 3.23
Wheat	$\hat{Y}_t = -1034.32 + 6.5235X_t$ $r^2 = 0.947671$ $S_1 = 152173.5$ D f = 48	$\hat{Y}_t = - 634.47 + 4.609359X_t$ $r^2 = 0.845047$ $S_2 = 34120.77$ D f = 19	$\hat{Y}_t = -959.754 + 6.29514X_t$ $r^2 = 0.872049$ $S_3 = 70105.19$ D f = 27
	$S_4 = 104225.96$	$S_5 = 47947.54$ F = 10.580	Table value = 3.23
Coarse Cereals	$\hat{Y}_t = 548.6329 - 0.63438X_t$ $r^2 = 0.52249$ $S_1 = 90343.51$ D f = 48	$\hat{Y}_t = 384.2216 – 0.22568X_t$ $r^2 = 0.040607$ $S_2 = 17317.76$ D f = 19	$\hat{Y}_t = 656.2041 – 1.01313X_t$ $r^2 = 0.384937$ $S_3 = 59147.31$ D f = 27
	$S_4 = 76465.07$	$S_5 = 13878.44$ F = 4.17	Table value = 3.23
Total Cereals	$\hat{Y}_t = 11573.08 - 9.7744X_t$ $r^2 = 0.242794$ $S_1 = 10348896$ D f = 48	$\hat{Y}_t = -3947.85 + 4.9989X_t$ $r^2 = 0.258661$ $S_2 = 772155.6$ D f = 19	$\hat{Y}_t = 4938.947 – 2.85496X_t$ $r^2 = 0.028346$ $S_3 = 2752104$ D f = 27
	$S_4 = 3524259.6$	$S_5 = 2752104$ F = -17.96	Table value = 3.23

Source: Ministry of Agriculture &Farmers Welfare, Government of India, Coffee board of India, Tea board of India, Reserve Bank of India- Handbook of Statistics on the Indian Economy – 2020-21. Authors Calculation.

Table 1 shows the structural stability of the regression equation for foodgrains – cereals such as rice, wheat, and coarse cereals. The critical $F_{2,46}$ is estimated to be 3.23, and since the observed test values for rice and total cereals were -22.42 and -17.96, respectively, which are less than the critical value, accept the null hypothesis. The structural stability of rice and total cereal production is unaffected. However, the F values for wheat and coarse cereals were 10.580 and 4.17, respectively, rejecting the null hypothesis that structural changes occur in the two foodgrains.

Table 2
Structural Stability of Regression Model – Food grains - Pulses

Pooled sample	Period I	Period II
$\hat{Y}_t = -215.012 + 0.7369X_t$ $r^2 = 0.7369$ $S_1 = 16594.13$ D f = 48	$\hat{Y}_t = - 117.744 + 1.019817X_t$ $r^2 = 0.50121$ $S_2 = 1984.939$ D f = 19	$\hat{Y}_t = -175.468 + 1.404482X_t$ $r^2 = 0.902859$ $S_3 = 3686.69$ D f = 27
$S_4 = 5671.629$	$S_5 = 10922.501$ F = 44.293	Table value = 3.23

Source: Ministry of Agriculture & Farmers Welfare, Government of India, Coffee board of India, Tea board of India, Reserve Bank of India- Handbook of Statistics on the Indian Economy – 2020-21. Authors Calculation.

The structural stability of regression equation for pulses were shown in the table 2, indicates that the production function of pulses in the two periods are different, this may be due to the intercept values or the slope coefficient. The pooled regression coefficient was 73.69%, implies that if the change in the area under the cultivation of pulses were influenced by production of pulses. In the period I, its only 50.121% to the period II were 90.2859%.

Table 3
Structural Stability of Regression Model – Total Food grains

Pooled sample	Period I	Period II
$\hat{Y}_t = 2687.5 – 0.67413X_t$ $r^2 = 0.00148$ $S_1 = 15302524$ D f = 48	$\hat{Y}_t = -4035.9 + 4.2481X_t$ $r^2 = 0.30462$ $S_2 = 795349.8$ D f = 19	$\hat{Y}_t = -7789.69 + 8.1662X_t$ $r^2 = 0.387496$ $S_3 = 2314734$ D f = 27
$S_4 = 3,110,083.8$	$S_5 = 12,192,440.2$ F = 90.167Table value = 3.23	

Source: Ministry of Agriculture & Farmers Welfare, Government of India, Coffee board of India, Tea board of India, Reserve Bank of India- Handbook of Statistics on the Indian Economy – 2020-21. Authors Calculation.

The overall significance of the structural stability regression for the total foodgrains, included the rice, wheat, coarse cereals and pulses indicates that the pooled sample the intercept was 2687.5 and the slope coefficient were 0.67413, which implies that the one lakh hectare of area under the cultivation of foodgrains were by 67.413%. On the basis of the hypothesis, reject the null hypothesis; that is, production of total food grains in the two period were different due to the change in the area under the cultivation of foodgrains. The coefficient determination shows that only 0.148% influence of the area under the cultivation of foodgrains.

Table 4

Structural Stability of Regression Model – Major Commercial crops - Oilseeds

	Pooled sample	Period I	Period II
Groundnut	$\hat{Y}_t = 64.53235 + 0.64327X_t$ $r^2 = 0.00231$ $S_1 = 10745.25$ D f = 48	$\hat{Y}_t = -81.2559 + 1.950841X_t$ $r^2 = 0.712957$ $S_2 = 859.6071$ D f = 19	$\hat{Y}_t = 57.72738 + 0.259516X_t$ $r^2 = 0.037067$ $S_3 = 5946.063$ D f = 27
	$S_4 = 6805.67$	$S_5 = 3939.58$ F = 13.31	Table value = 3.23
Rapeseed & Mustard	$\hat{Y}_t = -38.3488 + 1.667971X_t$ $r^2 = 0.82012$ $S_1 = 5059.757$ D f = 48	$\hat{Y}_t = -32.2127 + 1.457132X_t$ $r^2 = 0.874528$ $S_2 = 265.3819$ D f = 19	$\hat{Y}_t = -1.93399 + 1.10892X_t$ $r^2 = 0.298971$ $S_3 = 3959.814$ D f = 27
	$S_4 = 4225.196$	$S_5 = 834.561$ F = 4.54	Table value = 3.23
Soyabean	$\hat{Y}_t = -2.66311 + 1.083094X_t$ $r^2 = 0.946988$ $S_1 = 5627.031$ D f = 48	$\hat{Y}_t = -0.55285 + 0.850029X_t$ $r^2 = 0.94023$ $S_2 = 56.39688$ D f = 19	$\hat{Y}_t = -4.21425 + 1.102719X_t$ $r^2 = 0.804221$ $S_3 = 5434.405$ D f = 27
	$S_4 = 5490.8$	$S_5 = 136.231$ F = 0.5707	Table value = 3.23
Total Oilseeds	$\hat{Y}_t = -225.941 + 1.85881X_t$ $r^2 = 0.843722$ $S_1 = 51922.58$ D f = 48	$\hat{Y}_t = -143.432 + 1.38931X_t$ $r^2 = 0.92993$ $S_2 = 1372.215$ D f = 19	$\hat{Y}_t = -171.267 + 1.6674X_t$ $r^2 = 0.366778$ $S_3 = 42101.48$ D f = 27
	$S_4 = 43473.69$	$S_5 = 8448.89$ F = 4.469	Table value = 3.23

Source: Ministry of Agriculture & Farmers Welfare, Government of India, Coffee board of India, Tea board of India, Reserve Bank of India- Handbook of Statistics on the Indian Economy – 2020-21. Authors Calculation.

Table 4 shows the structural stability regression equation for the major commercial crops; of these, the calculated value of the groundnut (F = 4.469), rapeseed, and mustard (4.54) exceeds the table value (3.23), rejecting the null hypothesis, implying that the agricultural production of these crops differed between the two periods. There is no structural change in the care of soyabean (0.57.7) over the two periods. The sum of the oilseeds refutes the null hypothesis, indicating that structural stability occurred over two periods.

Table 5

Structural Stability of Regression Model – Other major Commercial Crops

	Pooled sample	Period I	Period II
Coffee	$\hat{Y}_t = -19.1179 + 761.0677X_t$ $r^2 = 0.867198$ $S_1 = 4710018$ D f = 48	$\hat{Y}_t = -237.891 + 818.9277X_t$ $r^2 = 0.425258$ $S_2 = 1767012$ D f = 19	$\hat{Y}_t = 960.352 + 507.455X_t$ $r^2 = 0.732135$ $S_3 = 1470698$ D f = 27
	$S_4 = 3237.710$	$S_5 = 1472.308$ F = 10.45	Table value = 3.23
Cotton(Lint)	$\hat{Y}_t = -308.298 + 5.18488X_t$ $r^2 = 0.871784$ $S_1 = 66557.68$ D f = 48	$\hat{Y}_t = 20.02066 + 0.710505X_t$ $r^2 = 0.03795$ $S_2 = 4397.519$ D f = 19	$\hat{Y}_t = -266.53 + 4.837985X_t$ $r^2 = 0.816207$ $S_3 = 50424.57$ D f = 27
	$S_4 = 54822.089$	$S_5 = 11735.591$ F = 4.923	Table value = 3.23
Raw Jute &Mesta	$\hat{Y}_t = 115.3092 – 2.2079X_t$ $r^2 = 0.035284$ $S_1 = 15806.38$ D f = 48	$\hat{Y}_t = 2.569414 + 6.796706X_t$ $r^2 = 0.449069$ $S_2 = 2385.532$ D f = 19	$\hat{Y}_t = 89.7153 + 1.708458X_t$ $r^2 = 0.043706$ $S_3 = 2247.717$ D f = 27
	$S_4 = 4633.249$	$S_5 = 11173.131$ F = 55.46	Table value = 3.23
Sugarcane	$\hat{Y}_t = -1148.33 + 95.24171X_t$ $r^2 = 0.959316$ $S_1 = 1335372$ D f = 48	$\hat{Y}_t = -1136.02 + 94.10343X_t$ $r^2 = 0.901528$ $S_2 = 223959$ D f = 19	$\hat{Y}_t = -747.709 + 86.54034X_t$ $r^2 = 0.835524$ $S_3 = 1040550$ D f = 27
	$S_4 = 1264509$	$S_5 = 70863$ F = 1.288	Table value = 3.23

Tea	$\hat{Y}_t = -4978.69 + 2803.911X_t$ $r^2 = 0.906971$ $S_1 = 31034368$ D f = 48	$\hat{Y}_t = -8856.23 + 3798.858X_t$ $r^2 = 0.897699$ $S_2 = 1641441$ D f = 19	$\hat{Y}_t = -3861.33 + 2597.718X_t$ $r^2 = 0.744641$ $S_3 = 27216716$ D f = 27
	$S_4 = 28858157$	$S_5 = 2176211$ F = 1.734	Table value = 3.23
Tobacco	$\hat{Y}_t = 0.307189 + 1.2683X_t$ $r^2 = 0.197868$ $S_1 = 86.50132$ D f = 48	$\hat{Y}_t = 1.841501 + 0.637091X_t$ $r^2 = 0.163035$ $S_2 = 7.693701$ D f = 19	$\hat{Y}_t = -1.34911 + 1.88065X_t$ $r^2 = 0.563079$ $S_3 = 1470698$ D f = 27
	$S_4 = 33.2677$	$S_5 = 53.23362$ F = 36.808	Table value = 3.23

Source: Ministry of Agriculture & Farmers Welfare, Government of India, Coffee board of India, Tea board of India, Reserve Bank of India- Handbook of Statistics on the Indian Economy – 2020-21. Authors Calculation.

The estimated F values for Coffee (10.45), Cotton (Lint) (4.923), Raw jute and Mesta (55.46), and Tobacco (36.808) are more than the table value, indicating that the structural change happened over two time periods, according to the structural stability regression equation shows in the table 5. The estimated value for Sugarcane (1.288) and Tea (1.734) is less than the table value, indicating that there is no structural change in the two-time period of the crops.

III. Conclusion

The agriculture and allied sectors in gross value added (GVA) of India at current prices stood at 17.8 % in last years. Although the Indian economy is a developing one, it remains an agrarian economy because agriculture is the primary source of income for the vast majority of the population. Two alternative regression models are being compared to the structural stability regression model. Rice's structural stability is unchanged, as is total cereal production. Wheat and coarse cereals had F values of 10.580 and 4.17, respectively, refuting the null hypothesis of structural changes in the two foodgrains.Because of the shift in the area under cultivation of foodgrains, the total food grain production in the two periods differed. Over the two periods, there is no structural change in soyabean care. The total number of oilseeds shows that structural stability was achieved throughout two periods. Coffee, Cotton (Lint), Raw jute and Mesta, and Tobacco have estimated values that are higher than the table value, showing that the structural shift occurred during two time periods.

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